Insect pest management approaches among currently recommended sugarcane varieties in Louisiana

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INSECT PEST MANAGEMENT APPROACHES AMONG CURRENTLY RECOMMENDED SUGARCANE VARIETIES IN LOUISIANA

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ABSTRACT

The sugarcane borer, *Diatraea saccharalis* (F.), (Lepidoptera: Crambidae), is responsible for more than 90% of the total insect damage to sugarcane in Louisiana. The decision to apply insecticides is complex and influenced by numerous variables. Included among these variables are insect infestation levels, varieties, weather conditions, production input levels, and environmental concerns. Predicting damage that may result from infestations occurring at a particular time of the crop production season is also important. The objective of this research was to evaluate the impact of these variables on sugarcane borer populations and subsequent yield loss. Results from a two-year survey indicated a state average of 2% sugarcane borer damaged internodes in the 2000 growing season and revealed that most fields received only one application of insecticide. However, in Central Louisiana, where spring rainfall occurred, some fields required three insecticide applications for sugarcane borer control. In 2001, the survey showed a state average of 4% bored internodes, and most fields received less than one application of insecticide. In a two-year sugarcane borer management study conducted at the St. Gabriel Research Station, St. Gabriel, Louisiana, results from the plant cane crop (2001) and from the first ratoon crop (2002) showed some differences among the variety-management threshold regimes in percent bored internodes resulting from sugarcane borer larval feeding. For the resistant variety HoCP85-845, all thresholds for percent bored internodes were not significantly different from the untreated control, suggesting some flexibility in management when using the recommended 5% threshold level. In 2001for the highly susceptible variety HoCP91-555, the 10 percent threshold had significantly higher percent bored internodes than did the 5% and 5%/10% threshold treatments. HoCP91-555 also reached insecticide treatment levels before the other varieties. The selected threshold management regimes varied insecticide

application timing and frequency to maintain sugarcane borer infestations below the designated thresholds. This study showed the importance of rainfall as a contributing factor for an increase in sugarcane borer levels and the role of resistant and highly susceptible varieties in a management strategy.

CHAPTER 1

INTRODUCTION AND REVIEW OF LITERATURE

Introduction

The sugarcane borer, *Diatraea saccharalis* (F.), (Lepidoptera: Crambidae), in most years, is the most destructive insect pest attacking sugarcane (interspecific hybrid of *Saccharum* spp.) in Louisiana and is responsible for greater than 90% of the total insect damage to this crop (Reagan 2001). The sugarcane borer was first introduced into the United States from the West Indies around 1855 (Williams et al. 1969). In addition to sugarcane, the sugarcane borer attacks several other crops in the Gramineae family including: corn, *Zea mays* L.; rice, *Oryza sativa* L.; and sweet sorghum, *Sorghum bicolor* L.; (Reagan and Flynn 1986). Non-cultivated grass species including johnsongrass, *Sorghum halepense* L. are important non-cultivated hosts (Bessin and Reagan 1990). Corn is known to enhance infestations and management problems with the sugarcane borer, particularly when populations immigrate from senescing cornfields and are in synchrony with periods of high larval survival on sugarcane (Flynn and Reagan 1984, Flynn et al. 1984).

Sugarcane borer infestations reduce total cane biomass and cane quality. Tunneling by larvae within the stalk renders the stalks more susceptible to lodging and breakage, reduces plant growth, and causes it to sucker. Suckering creates late-season green biomass that contributes to low sugar recovery. Larvae tunnels also serve as points of entry of pathogens, especially red rot diseases (Ogunwolu et al. 1991).

Sugarcane borer adults emerge in the spring, mate, and deposit eggs (up to 700) in clusters of 30 to 50 on the upper leaves (predominantly on the ventral surface) of host plants. Larvae emerge from egg masses after four to five days and migrate near the growing point of the plant (whorl) where they begin to feed. After larvae develop to the third instar stage (earlier on some varieties), they begin to tunnel into the stalk of the plant. After completing the fifth instar stage (a small percentage, frequently females molt to the sixth or seventh instar stage), the larvae pupate and emerge as adults(Roe et al. 1982). During the fall in Louisiana, the larvae diapause and overwinter in cane pieces that remain in the field after harvest or in the plant ratoon in the field (Reagan 1981). Four to five generations of the sugarcane borer occur each year in Louisiana (Hensley 1971, Reagan and Martin 1982).

Review of Literature

Since its adoption, the insect pest management system in Louisiana sugarcane has stressed the importance of varietal resistance to the sugarcane borer (Reagan and Martin 1989), scouting and proper timing of insecticide applications (Hensley 1971, White 2000), and preservation and enhancement of natural control from beneficial insects (Reagan et al. 1972, Ali and Reagan 1985). The emphasis on a balance of multiple control tactics has been cited as a necessary approach to maintaining the permanency of Louisiana's sugarcane IPM system (Bessin et al.1990a).

Predation, primarily by imported fire ants, contributes to the reduction of sugarcane borer injury on sugarcane by approximately 16%. Varietal resistance in some years has accounted for nearly 24% of sugarcane borer control, and properly timed insecticide applications provide nearly 60% sugarcane borer control (Bessin et al. 1990a). In terms of the suppression of sugarcane borer adult emergence from the sugarcane stalks, Bessin et al. (1990b) reported that varietal resistance contributed 42% control compared to 47% control from the use of properly timed insecticide applications. By 2000, the average number of insecticide applications targeting sugarcane borer had declined by greater than 90% (twelve to less than one) since 1960 (Reagan and Martin 1982, Hensley 1971). The use of insecticides in the Louisiana sugarcane industry remains the only means of achieving rapid suppression of sugarcane borer infestations below economic injury levels.

Varietal resistance was a major insect management component during the mid 20th century with varieties such as NCo310, CP52-68, and CP65-357, but has been reduced from its earlier full potential in the Louisiana sugar industry. Reasons for neglect of genetic resistance in new sugarcane varieties are: (1) effective and economical control of the sugarcane borer with insecticides, (2) lack of emphasis on selecting for insect resistance in experimental varieties because of a strong emphasis on selection for other criteria in the varietal programs, such as yield (Hensley and Long 1969), and (3) a germplasm base lacking sufficient genetic variation for traits that confer resistance to sugarcane borer. The release of LCP85-384 in 1993 and quick adoption of the new variety by growers has shifted the germplasm base in the Louisiana sugarcane variety development programs. Approximately 88% of Louisiana sugarcane acreage in 2003 was planted to the sugarcane borer susceptible variety LCP85-384 (B.L. Legendre, personal communications). Due to cooperative efforts and improved methods for evaluating varietal resistance to sugarcane borer, scientists at the LSU AgCenter and the USDA-ARS Sugarcane Research Unit in Houma, Louisiana, have made progress in selecting and evaluating new experimental varieties with improved resistance to sugarcane borer and other insect pests.

In addition to assessing relative plant injury, the LSU AgCenter technique also looks at moth production (Bessin et al. 1990b). Potential new varieties are evaluated for insect susceptibility several years before release to the sugarcane industry. An important role of an extension or research entomologist is to inform growers and their consultants how best to manage varieties once they are released for commercial production (White 2000).

The determination of whether a pest density has the potential to cause economic injury is one of the most important decisions in any IPM program. This decision must be based upon a reliable estimate of the economic threshold and an adequate sampling technique (Pedigo and Zeiss 1996). The economic threshold concept is defined as the pest density at which management tactics, such as chemical control, should be applied. The cost of the management tactic, the market value of the crop, the amount of injury per pest, and the reduction of pest densities due to the management tactic applied should be considered when calculating the economic threshold (Stern 1973).

Infestation levels of the sugarcane borer are monitored from mid-June through mid-September. Agricultural consultants frequently vary action thresholds from the recommended 5% benchmark level depending on a number of factors including: economics of the grower's production system, variety, crop age, stage of crop, and application method (ground vs. aerial – the ground rate can be reduced by one-third and still be equivalent to the aerial rate for insecticide effectiveness). In practice, treatment thresholds for management of the sugarcane borer in Louisiana range from 2% to 10% of plants infested with sugarcane borer larvae outside the stalk (Schexnayder et al. 2001). The 5% stalk infestation criterion used in Louisiana was established by Hensley et al. (1971) as the insecticide treatment threshold for the sugarcane borer and is based on the premise that uncontrolled infestations at that level will result in 10% internodes bored during a crop production season. The economic loss per acre associated with injury of 10% bored internodes exceeds the cost of one insecticide application including consultant and applicator fees (Hensley 1971).

As growers seek to remain competitive, a key question is how does the current status of the sugarcane borer and insect pest management, in general, fit within the overall context of sugarcane production economics? Growers and consultants must be informed with accurate and current data to answer this question. Faced with shrinking profit margins and increased emphasis on sugarcane quality, the grower needs to make certain that an insecticide application is justified. At the same time, growers must insure that economic losses will not occur from either poor insecticide application timing or applications made under less than optimum conditions (White 2000).

With the exception of the publication of Ali and Reagan (1985), during the last 30 years of insect pest management in the Louisiana sugarcane industry, relatively little in-depth collaboration has occurred between entomologists and agricultural economists. Clearly, the role of economics in insect pest management decisions (both long and short term) has not been adequately utilized in sugarcane production.

The process of determining if an insecticide treatment is warranted can be influenced by many variables (i.e. infestation levels on different varieties, weather conditions, economics of the grower, environmental concerns, etc.); not all are thoroughly understood. The goal of this research was to develop additional insight into these variables thus allowing the sugarcane industry greater flexibility to control the sugarcane borer while maintaining confidence that yield losses and increases in sugarcane borer populations can be avoided. Therefore, the objectives of the following research were: (1) to survey the Louisiana sugarcane industry during 2000 and 2001 and assess the severity of the sugarcane borer, and (2) to investigate the use of selected sugarcane borer management thresholds for the four recommended sugarcane varieties in Louisiana.

CHAPTER 2

AN INSECT PEST MANAGEMENT SURVEY OF SUGARCANE DURING 2000 AND 2001

Introduction

The sugarcane borer, *Diatraea saccharalis* (F.), (Lepidoptera: Crambidae), for many years, has been the most destructive insect pest attacking sugarcane (interspecific hybrid of *Saccharum* spp.) in Louisiana, and is responsible for more than 90% of the total insect damage to this crop (Reagan 2001). Sugarcane borer larvae damage the plant in several ways; the result is reduced total biomass, as well as quantity and quality of sugar. Tunneling in the stalk reduces stalk weight as well as making the stalk susceptible to lodging and breakage. Larval entry holes also serve as a point of entry for pathogens, especially red rot diseases (Ogunwolu et al. 1991). The larval feeding also reduces plant growth and causes the stalk to sucker with the inhibition of apical dominance when the apical bud is killed. This damage also increases late-season green biomass that reduces sugar quantity and quality.

Sugarcane borer moths emerge in the spring and deposit eggs (up to 700) in clusters of 30 to 50 on the upper leaves (predominantly on the ventral surface) of host plants. Larvae emerge from egg masses after four to five days and migrate to the growing point of the plant (whorl) where they begin to feed. After the larvae develop to the third instar stage (earlier on some varieties), they begin to tunnel into the stalk. After completing the fifth instar, the sugarcane borer larvae pupate, emerge as adults, and continue the life cycle (Roe et al. 1982). During the fall months in Louisiana, the larvae diapause and overwinter in harvest residue or in the plant ratoon that remains in the field, and also in wild hosts (Reagan 1981). Four to five generations of the sugarcane borer occur in Louisiana (Reagan and Martin 1982).

An extensive survey to determine levels of sugarcane borer damage has not been conducted in the Louisiana sugarcane industry for many years. As sugarcane growers seek to remain competitive, it becomes even more important to document the current pest status of the sugarcane borer. A survey of the Louisiana sugarcane industry was conducted during the 2000 and 2001 growing season with the following objectives: (1) to determine overall level of injury caused by the sugarcane borer; (2) to document insecticide use patterns across production regions, and (3) to examine the major environmental factors influencing any observed differences.

Materials and Methods

An experimental assessment was designed to determine the severity of the sugarcane borer injury to the Louisiana sugarcane industry. Eight regions were designated to permit a systematic survey the sugarcane growing parishes in Louisiana during 2000 and 2001. The regions included: (1) Central (Rapides Parish), (2) Southwest (Jefferson Davis Parish), (3) Upper River (Point Coupee and Iberville Parishes), (4) Upper Lafourche (Assumption Parish), (5) Lower Lafourche (Terrebonne and Lafourche Parishes), (6) Vermilion (Vermilion and Lafayette Parishes), (7) Teche (St. Martin and Iberia Parishes), and (8) Lower River (St. James Parish) (Figure 2.1).

Two farms in each region were chosen to evaluate the level of sugarcane borer injury. Two plant cane and two ratoon fields planted to sugarcane borer susceptible varieties and two plant cane and two ratoon fields planted to sugarcane borer moderate or resistant varieties were surveyed. Some of the original aspects of this study were not reported due to the significant amount of unavailable or non-reporting of data at harvest by both growers and consultants. Percent bored internodes, insecticide application frequency, and rainfall were averaged for each region.

In 2000 and 2001, 120 and 88 fields, respectively, were sampled. The rapid adoption of LCP85-384 by the Louisiana sugarcane industry made the field selection regime less balanced in the 2001 study (88 fields versus the original 120 planned).

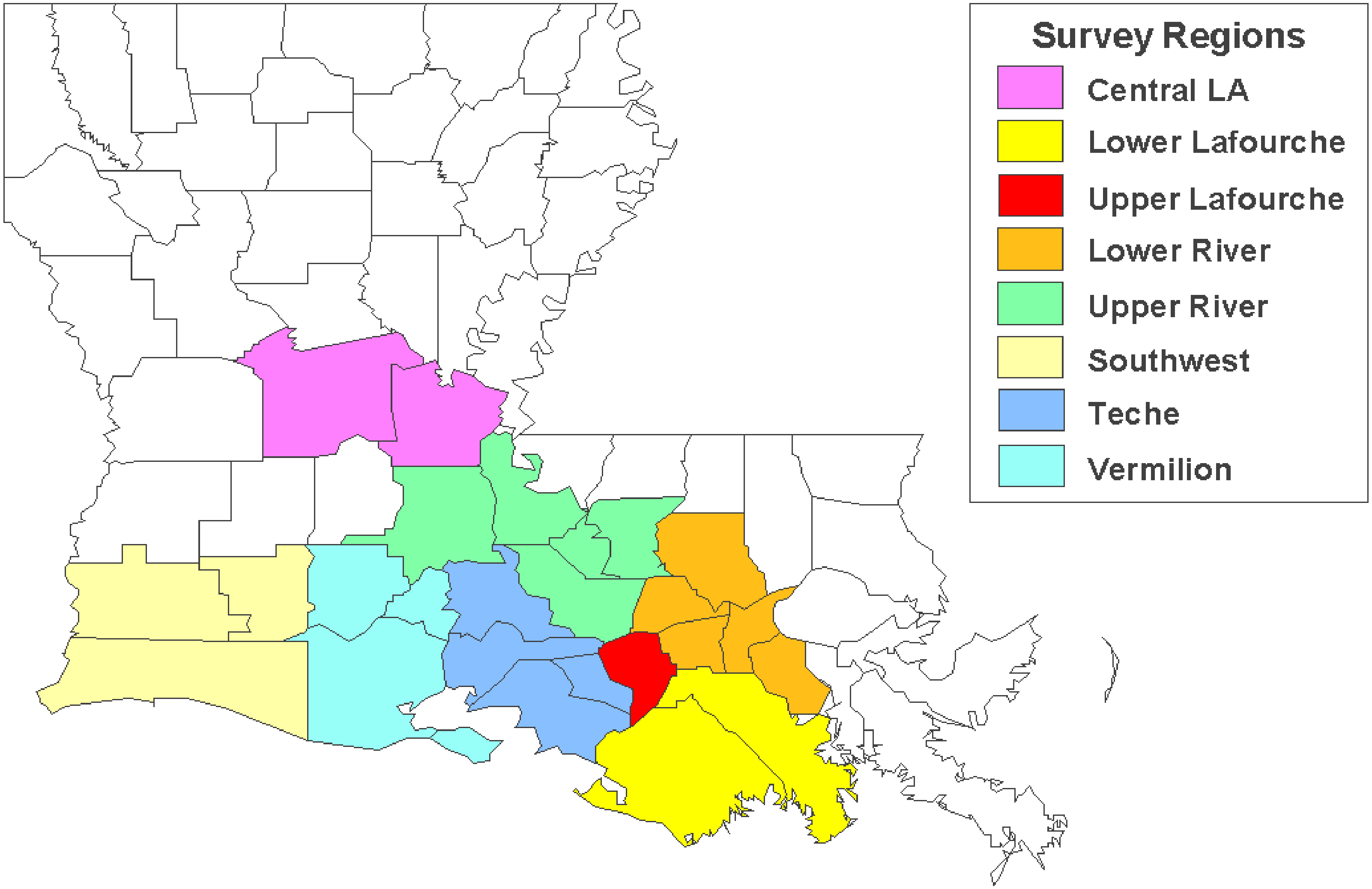

Figure 2.1. Sugarcane borer injury survey regions in Louisiana during 2000 and 2001.

Spring deadhearts (number and total stand in two 0.002 ha samples per field) and end-of-season percent bored internodes (50 stalks sampled with bored internodes counted by position from four locations in each field) were collected (hand cut) to determine the level of sugarcane borer injury. The majority of the cane in 2000 and 2001 was severely lodged at the time of harvest. Insecticide application information (application frequency per year) was obtained from either the grower or consultant. Rainfall information was obtained for 2000 and 2001 from the Louisiana Office of State Climatology.

A sucrose analysis was conducted on each sample at the USDA-ARS Sugarcane Research Unit at Houma, Louisiana. Fiber was determined by shredding of the stalk with a pre-breaker manufactured by Cameco Industries prior to juice extraction. The method used was similar to the one reported by Gravois and Milligan 1992 with the exception that a 1000g fiber sample was used for juice extraction. Brix and pol reading were used to determine theoretical recoverable sugar (TRS, g/kg) (Gravois et al.1991). A significant amount of the sucrose and fiber data for 2000 and 2001 was lost due to an unfortunate computer malfunction. Therefore, the sucrose and fiber data for this study were not reported.

Results

During 2000, a total of 5,350 stalks yielding a total of 65,081 internodes were collected from the eight sugarcane growing regions. The total number of internodes bored was 1,331, for an average of 2.05% bored internodes. Spring sugarcane borer deadhearts averaged 665 per hectare for the 2000-growing season and ranged from a high of 1,620 deadhearts in the Central region to a low of 271 in the Lower Lafourche region (Table 2.1).

In 2000, a long period of low rainfall occurred in all of the sugarcane growing regions except in the Central Louisiana region where high early rainfall occurred (Table 2.2). The rainfall in the spring of 2000 ranged from 2.2cm in the Lower Lafourche region to a high of

Table 2.1. Number of sugarcane borer spring deadhearts per hectare in the eight regions of the Louisiana sugarcane industry in 2000 and 2001.

	Sugarcane borer spring deadhearts per hectare[a]	
Selected regions	2000	2001
Central	1,620a	312b
Southwest	401b	1,320ab
Upper River	360b	379ab
Upper Lafourche	974ab	379ab
Lower Lafourche	271b	1,500a
Vermilion	595b	720ab
Teche	526b	420ab
Lower River	571b	300b

[a]Each value represents a mean of 16 fields in each region each year except the Southwest region, which had eight fields evaluated each year, and means followed by the same letter in a column are not significantly different ($P \leq 0.05$,LSD).

Table 2.2. Rainfall, insecticide application frequency, and percent bored internodes comparisons in the eight regions of the Louisiana sugarcane industry in 2000.

Selected regions	Rainfall (centimeters)[a] Apr - May	Jun – Jul	Aug – Sep	Total	Insecticide application frequency	Percent bored internodes[b]
Central 2000	31.2	19.1	7.8	58.1	2.5	4.04a
(+/-) Normal	7.7	-3.6	-14.1			
Southwest 2000	24.7	20.7	16.5	61.9	0.0	2.91ab
(+/-) Normal	0.2	-5.6	-10.4			
Upper River 2000	4.9	21.9	5.1	31.9	0.1	2.61ab
(+/-) Normal	-20.8	-3.2	-21.0			
Upper Lafourche 2000	2.6	20.6	29.1	52.3	0.0	2.44ab
(+/-) Normal	-21.7	-52.3	-5.8			
Lower Lafourche 2000	2.2	33.0	26.3	61.5	0.2	2.38ab
(+/-) Normal	-21.1	1.5	-7.9			
Vermilion 2000	7.7	20.5	22.7	50.9	0.0	1.25b
(+/-) Normal	-15.9	-12.5	-8.1			
Teche 2000	2.7	30.4	24.3	57.4	0.0	1.06b
(+/-) Normal	-19.4	-3.4	-6.9			
Lower River 2000	3.1	17.4	22.5	43.0	0.1	0.73b
(+/-) Normal	-20.0	-13.0	-7.2			

[a]Weather data adapted from Climatologically Data Louisiana (LOSC 2000).
[b]Means within a column followed by the same letter are not significantly different ($P<0.05$,Proc Mixed, Tukey-Kramer).

31.2cm in the Central Louisiana region. The total rainfall for the growing season ranged from a high of 61.9cm in the Southwest region to a low of 31.9cm in the Upper River region.

Some fields in the Central region required two to three insecticide applications for sugarcane borer control in 2000. The insecticide application frequency ranged from no application of insecticide required for the Southwest, Upper Lafourche, Vermilion, and Teche regions to 2.5 applications for the Central Region (Table 2.2).

In 2001, a total of 3,100 stalks yielding a total of 39,807 internodes was sampled during 2001. The total number of internodes bored was 1,470, for an average of 3.69 percent bored internodes. Sugarcane borer spring deadhearts averaged 666 per hectare for the 2001-growing season and ranged from a high of 1,500 in the Lower Lafourche region to a low of 300 in the Lower River region (Table 2.1).

The rainfall in the spring of 2001 ranged from 0.6cm in the Lower Lafourche region to a high of 20.1cm in the Lower River region (Table 2.3). The total rainfall for the growing season ranged from a high of 117.9cm in the Upper Lafourche region to a low of 70.5 in the Central region. Most fields received less than one application, but a few fields received two applications for sugarcane borer control. The insecticide application frequency ranged from 0.5 applications of insecticide required for the Upper Lafourche, Vermilion, and Lower River regions to one application for the Southwest and Lower Lafourche regions.

Discussion

Observations throughout the years have led sugarcane industry consultants, growers, and researchers to suggest that frequent rainfall is an important factor in increasing sugarcane borer infestations and thus insecticide use patterns. The correlations between rainfall at a particular time and the amount of insecticide used, spring deadhearts, or end-of-season percent bored internodes were not significant in this study.

Table 2.3. Rainfall, insecticide application frequency, and percent bored internodes comparisons in the eight regions of the Louisiana sugarcane industry in 2001.

Selected regions	Rainfall (centimeters)[a] Apr – May	Jun – Jul	Aug - Sep	Total	Insecticide application frequency	Percent bored internodes[b]
Central 2001	10.2	32.5	27.8	70.5	0.9	1.67c
(+/-) Normal	-13.3	9.9	6.0			
Southwest 2001	4.7	43.4	55.5	103.6	1.0	2.44bc
(+/-) Normal	-19.8	16.8	28.5			
Upper River 2001	5.9	65.2	30.4	101.5	0.8	6.27a
(+/-) Normal	-19.8	40.0	4.2			
Upper Lafourche 2001	6.9	73.4	37.6	117.9	0.5	2.29bc
(+/-) Normal	-17.5	39.8	2.7			
Lower Lafourche 2001	0.6	60.8	37.7	99.1	1.0	2.00bc
(+/-) Normal	-22.7	29.3	5.8			
Vermilion 2001	9.3	67.3	47.5	124.1	0.5	5.48ab
(+/-) Normal	-14.2	34.3	16.7			
Teche 2001	10.6	44.7	62.2	117.5	0.8	2.01c
(+/-) Normal	-11.6	11.0	30.9			
Lower River 2001	20.1	62.5	33.4	116.0	0.5	3.76abc
(+/-) Normal	-2.9	32.1	3.8			

[a]Weather data adapted from Climatologically Data Louisiana (LOSC 2001).
[b]Means within a column followed by the same letter are not significantly different ($P<0.05$,Proc Mixed, Tukey-Kramer).

However, in the areas that had high early rainfall and continued to receive frequent rainfall throughout the season, there were more insecticide applications and frequently a higher percentage of end-of-season bored internodes. Additional observations in 2003, support our findings. Heavy infestations of sugarcane borer populations were encountered this year following early rains in April and May. Continued rainfall in the months of June, July, and August further intensified problems. Many growers averaged between one and two applications, with a few growers requiring three applications.

Hensley (1971) documented that dry weather, especially in May and June when first generation larvae are infesting young tillers, can cause 50% mortality of sugarcane borer larvae. The biology of the sugarcane borer is well synchronized to that of sugarcane. Weather conditions favorable to rapid growth of the sugarcane plant (warm temperature and abundant rainfall) invariably result in rapid increase in populations of the sugarcane borer.

Holloway et al. (1928) stated that there was an inverse relationship between rainfall and sugarcane borer abundance in Louisiana and Puerto Rico. Heavy rainfall, and particularly winter rainfall result in flooding and depresses borer survival. Prolonged emersion of stalks kills over wintering larvae (Capinera 2001). Young larvae living in the whorl of sugarcane and corn are quite tolerant of short-term emersion, but heavy rainfall while they are dispersing could lead to death because they are washed from the plants. Wolcott (1915) also demonstrated that there was an inverse relationship between increased rainfall and the sugarcane borer instars found in the field, presumably because the larvae drown in the flooded tunnels. In addition to rainfall, cold winter temperatures are reported to depress larval survival rates in Louisiana (Capinera 2001).

Another important finding from this survey is that many growers do not budget for supplemental insecticide applications for sugarcane borer control. Our survey suggests that growers should budget for a minimum of two applications of insecticide for sugarcane borer control per hectare each production season. This would allow the grower flexibility in their overall farm budget during heavy sugarcane borer infestation production seasons to make needed applications and thus avoid severe economic losses due to the sugarcane borer. This is important in years like 2003 when growers needed to make two or greater insecticide applications.

CHAPTER 3

SUGARCANE BORER, *DIATRAEA SACCHARALIS* (F.), MANAGEMENT THRESHOLD ASSESSMENT ON FOUR LOUISIANA SUGARCANE CULTIVARS

Introduction

The sugarcane borer, *Diatraea saccharalis* (F.), (Lepidoptera: Crambidae), in most years, is the most destructive insect pest attacking sugarcane (interspecific hybrid of *Saccharum* spp.) in Louisiana. This sugarcane pest is responsible for more than 90% of the total insect damage to this crop (Reagan 2001). Sugarcane borer infestations reduce total cane biomass and cane quality. Tunneling by larvae within the stalk renders the stalks more susceptible to lodging and breakage, reduces plant growth, and causes it to sucker. Suckers create late-season green biomass that contributes to low sugar recovery.

For nearly four decades, sugarcane borer management in Louisiana sugarcane has stressed variety resistance to sugarcane borer (Reagan and Martin 1989), scouting and proper insecticide application timing (Hensley 1971, White 2000), and preserving natural enemies (Reagan et al. 1972, Ali and Reagan 1985) as means of controlling season long infestations. The average number of insecticide applications used against sugarcane borer has declined by greater than 90% (twelve to less than one) since 1960 (Reagan and Martin 1982, Hensley 1971). The use of insecticides in the Louisiana sugarcane industry remains the only means of achieving economical and rapid suppression of sugarcane borer infestations.

When 60% of the stalks in a field have produced visible internodes, the current recommendation for control of the sugarcane borer suggest an insecticide application when 5% or more of the stalks are infested with at least one larvae in the leaf sheaths. Typically, sugarcane borer populations are monitored from mid-June through mid-September (Pollet et al. 1996). The 5% stalk infestation criterion is based on the premise that uncontrolled infestations at that level will result in approximately 10% internodes bored during a crop season. The dollar loss per acre associated with 10% bored internodes is greater than the cost of one insecticide application needed to control continuous heavy seasonal infestations and includes cost of insecticide plus cost of consultant and cost of application services (Hensley 1971). Frequently agricultural consultants modify this threshold depending upon these factors: stage of crop, spray equipment (ground vs. aerial), crop diversity, and cultivar mix. In practice, spray thresholds for management of sugarcane borer in Louisiana range from 2% to 10% (stalks infested with sugarcane borer) (Schexnayder et al. 2001).

The objective of this research was to evaluate the economic threshold concept as it is currently being implemented in the Louisiana sugarcane industry along with the present sugarcane variety distribution. Specifically, are early infestations more important than later infestations, and should action thresholds vary for different varieties?

Materials and Methods

Four sugarcane borer insecticide management thresholds applied to four currently recommended commercial sugarcane varieties were evaluated in a randomized complete block experiment with four replications. Plots were three rows wide each (row width was 1.8m) by 12.2m long. The management threshold strategies were defined as follows: (1) treating all varieties at the 5% sugarcane borer infestation treatment threshold for the entire growing season, (2) treating all varieties at the 5% sugarcane borer infestation threshold level until August 1st and then treating all varieties at the 10% sugarcane borer infestation treatment threshold until September 15th (5%/10%), (3) treating all varieties at the 10% sugarcane borer infestation treatment threshold for entire growing season, and (4) non-treated control. The varieties included sugarcane borer resistant varieties CP70-321 and HoCP85-845 and sugarcane borer susceptible varieties LCP85-384 and HoCP91-555. The test was planted 16 August 2000 at the Sugar Research Station, St. Gabriel, Louisiana. Varieties were evaluated during the summers of

2001 (plant cane crop year) and 2002 (1st ratoon crop year). To minimize the variability in sugarcane borer infestations across years caused by natural arthropod predation (White 1980, Bessin and Reagan 1993), two applications of chlorpyrifos (Lorsban® 15G) were made. Applications were broadcasted at 16.8 kg/ha with a hand-cranked seeder in June and July of 2000 and 2001. Sugarcane borer larval infestations were monitored weekly by examining the leaf sheaths of 10 stalks per plot between 1 July and 15 September in both years. Infestations were monitored on the two outside rows in order to maintain the integrity of the center row for yield evaluation. Plots were treated with a CO_2 pressurized sprayer mounted on an all-terrain vehicle calibrated to deliver 93.3 l/ha and 241.15 kPa (10 GPA and 35 psi) when sugarcane borer infestations exceeded the designated treatment threshold. The spray boom covered three rows with one flat fan spray nozzle per six 1.8m of row width. The insecticide Tebufenozide (Confirm® 2F) was applied at the rate of 438.06 ml/ha (6 oz/a) tank mixed with a non-ionic surfactant (Latron CS-7®) – a blend of alkylaryl polyethoxylate and sodium salt of alkylsulfonatedalkylate at 0.25% vol/vol. Tables 3.1 and 3.2 show the insecticide application frequency and date of applications for 2001 and 2002, respectively.

Percent bored sugarcane internodes (%) (25 stalks per plot, total and by position of stalk), stalk weight (kg) (25 stalks collected per plot), fiber (%), theoretical recovery of sugar (g/kg), cane yield (mt/h), and sugar per hectare (kg/h) was collected at harvest (hand cut) on 25 November 2001 and 1 December 2002, respectively. During 2002, end-of-season sampling, in addition to assessing percent bored internodes by position, included dividing the sugarcane stalk samples for yield determinations into thirds, representing roughly early-season, mid-season, and late-season plant growth. Additionally, where there was borer injury affecting growth, care was taken to keep the suckers or side shoots in tact so as to affect sugar yield and quality.

Table 3.1. Insecticide application frequency and date of applications to control sugarcane borer infestations on the treatment regimes study conducted at St. Gabriel, Louisiana in 2001.

Treatment regimes		Insecticide application	Insecticide application
Variety	Management[a]	frequency	Date
CP70-321	5%	1.0	24 August
CP70-321	5%/10%	1.0	5 September
CP70-321	10%	1.0	5 September
CP70-321	Untreated	--	--
LCP85-384	5%	3.0	17 July, 24 August, and 5 September
LCP85-384	5%/10%	2.0	17 July and 5 September
LCP85-384	10%	2.0	24 August and 5 September
LCP85-384	Untreated	--	--
HoCP85-845	5%	1.0	24 August
HoCP85-845	5%/10%	1.0	24 August
HoCP85-845	10%	1.0	24 August
HoCP85-845	Untreated	--	--
HoCP91-555	5%	3.0	6 July, 24 August, and 5 September
HoCP91-555	5%/10%	3.0	6 July, 24 August, and 5 September
HoCP91-555	10%	1.0	5 September
HoCP91-555	Untreated	--	--

[a]Management threshold regimes are as follows: 5%: 5% sugarcane borer management threshold over entire season; 5%/10%: 5% sugarcane borer management threshold until Aug 1st and 10% sugarcane borer management threshold from Aug 1st through late season; 10%: 10% sugarcane borer management threshold over entire season; Untreated: Never treated during the season.

A sucrose analysis was conducted on each sample at the USDA-ARS Sugar Research Unit in Houma, Louisiana. Fiber (g/kg) was determined by shredding of the stalk (1000g) prior to juice extraction (Gravois and Milligan 1992). Brix and pol readings were used to determine theoretical recoverable sugar (TRS, g/kg) (Gravois et al. 1991). To determine total cane yield, plots were harvested with a sugarcane combine/weigh-wagon system, and each plot was weighed in a modified dump wagon fitted with load cells. Plots were not burned prior to harvest, and the combine's topper was not used to remove the immature internodes from each stalk. The majority of the cane in 2001 and 2002 was severely lodged at the time of harvest. Cane yield (mt/h) for each plot was estimated by plot weight, and weighed sugar yield (kg/h) was estimated as the product of cane yield and TRS. Data were analyzed using a mixed model analysis ($P \leq 0.05$, Proc Mixed) with means separated (Tukey-Kramer) by PDMIX800 for SAS Version 8 (Saxton 1998, SAS Institute 1999).

Table 3.2. Insecticide application frequency and date of applications to control sugarcane borer infestations on the treatment regimes study conducted at St. Gabriel, Louisiana in 2002.

Treatment regimes		Insecticide application	Insecticide application
Variety	Management[a]	frequency	date
CP70-321	5%	2.0	8 July and 19 August
CP70-321	5%/10%	2.0	8 July and 19 August
CP70-321	10%	1.0	19 August
CP70-321	Untreated	--	--
LCP85-384	5%	2.0	8 July and 12 August
LCP85-384	5%/10%	2.0	8 July and 19 August
LCP85-384	10%	2.0	15 July and 19 August
LCP85-384	Untreated	--	--
HoCP85-845	5%	1.0	15 July
HoCP85-845	5%/10%	1.0	19 August
HoCP85-845	10%	1.0	19 August
HoCP85-845	Untreated	--	--
HoCP91-555	5%	2.0	8 July and 12 August
HoCP91-555	5%/10%	2.0	8 July and 19 August
HoCP91-555	10%	2.0	15 July and 19 August
HoCP91-555	Untreated	--	--

[a]Management threshold regimes are as follows: 5%: 5% sugarcane borer management threshold over entire season; 5%/10%: 5% sugarcane borer management threshold until Aug 1st and 10% sugarcane borer management threshold from Aug 1st through late season; 10%: 10% sugarcane borer management threshold over entire season; Untreated: Never treated during the season.

Results

Plant Cane Crop Year (2001)

The analysis of variance of the 2001 plant cane crop data detected significant ($P \leq 0.05$) variety effects for middle and upper portion of stalk percent bored internodes, total whole stalk percent bored internodes, mean stalk weight, TRS, and weighed cane yield (Table 3.3). Significant differences between treatment regimes (threshold levels) were also detected for lower, middle, and upper portion of stalk percent bored internodes, and total whole stalk percent bored internodes. Significant variety*treatment interaction effects for middle and upper portion of stalk percent bored internodes, and total whole stalk percent bored internodes were detected.

Stalk weight was significantly different between CP70-321 and HoCP85-845, with CP70-321 having the larger mean stalk weight (Table 3.4). Stalk weight for both of those varieties were significantly greater than LCP85-384 and HoCP91-555. For TRS, CP70-321, HoCP85-845, and LCP85-384, were not significantly different from each other. HoCP85-845 TRS was significantly higher than HoCP91-555. A Type II error occurred for weighed cane yield due to the fact that the probability shows significance ($P=0.0292$), but no separation of means were detected by SAS at the $P=0.05$ significance level. There was a thirteen-metric ton difference per hectare between the lowest yielding variety, LCP85-384, and the two top yielding varieties, CP70-321 and HoCP91-555, for weighed cane yield.

A significant variety*threshold interaction require means to be reported by variety and threshold. Means were not different among the following variety-management threshold regimes (CP70-321 5%, 5%/10%, and 10%; HoCP85-845 5%, 5%/10%, and 10%; LCP85-384 5%, 5%/10%, and 10%; HoCP91-555 5%, 5%/10%, and 10%) [Table 3.5] for percent bored internodes. Except for the untreated HoCP85-845, all variety-management threshold regime means were significantly different from their corresponding untreated regimes ($P = <0.0001$).

Table 3.3. Analysis of variance of fixed effects for the plant cane sugarcane borer management threshold experiment involving four sugarcane varieties conducted at St. Gabriel, Louisiana in 2001.

Source	Lower portion of stalk percent bored internodes	Middle portion of stalk percent bored internodes	Upper portion of stalk percent bored internodes	Total whole stalk percent bored internodes	Mean stalk weight	Fiber	TRS	Cane yield (Weighed)	Sugar yield (Weighed)
	P-value								
Variety	0.1483	<0.0001	0.0002	<0.0001	<0.0001	0.7623	0.0335	0.0292	0.3279
Treatment	0.0026	<0.0001	<0.0001	<0.0001	0.4451	0.9205	0.5456	0.1088	0.6300
Variety*Treatment	0.8219	0.0003	0.0003	<0.0001	0.4683	0.4900	0.2762	0.4224	0.1359
	%								
CV (%)	100.0	50.0	43.2	33.8	8.1	22.7	9.7	11.6	14.6

Table 3.4. Variety means of the plant cane study at St. Gabriel, Louisiana in 2001.

Variety	Mean stalk weight[a] (kg)	Total whole stalk TRS[a] (g/kg)	Weighed cane yield[a] (mt/h)
CP70-321	1.4a	104ab	125a
HoCP85-845	1.2b	106a	114a
HoCP91-555	1.0c	97b	125a
LCP85-384	1.0c	105ab	112a
P > F	<0.0001	0.0335	0.0292

[a]Means within a column followed by the same letter are not significantly different (P<0.05, Proc Mixed, Tukey-Kramer).

Table 3.5. Treatment by variety means for sugarcane borer management threshold study conducted at the St. Gabriel Sugar Research Station, St. Gabriel, Louisiana, 2001.

Variety	Management threshold regimes[a]	Insecticide application frequency	Total whole stalk percent bored internodes[b,c]
CP70-321	5%	1.0	5.4ef
CP70-321	5%/10%	1.0	8.1cdef
CP70-321	10%	1.0	7.1def
CP70-321	Untreated	--	14.6bcd
LCP85-384	5%	3.0	5.1ef
LCP85-384	5%/10%	2.0	7.9cdef
LCP85-384	10%	2.0	13.6bcde
LCP85-384	Untreated	--	19.6b
HoCP85-845	5%	1.0	4.3f
HoCP85-845	5%/10%	1.0	5.4ef
HoCP85-845	10%	1.0	5.5ef
HoCP85-845	Untreated	--	10.5cdef
HoCP91-555	5%	3.0	5.0ef
HoCP91-555	5%/10%	3.0	5.3ef
HoCP91-555	10%	1.0	16.4bc
HoCP91-555	Untreated	--	30.1a
P > F			<0.0001

[a]Management threshold regimes are as follows: 5%: 5% sugarcane borer management threshold over entire season; 5%/10%: 5% sugarcane borer management threshold until Aug 1st and 10% sugarcane borer management threshold from Aug 1st through late season; 10%: 10% sugarcane borer management threshold over entire season; Untreated: Never treated during the season.
[b]25 stalks per plot were harvested on Nov. 25, 2001 and evaluated for bored internodes.
[c]Means within a column followed by the same letter are not significantly different ($P<0.05$, Proc Mixed, Tukey-Kramer).

However, the management regimes required different insecticide application frequencies to maintain sugarcane borer infestations below the designated thresholds in this study. HoCP91-555 required three applications of insecticide during the growing season for both the 5% and 5%/10% management regimes, and two applications of insecticide for the 10% management regime. LCP85-384 required three applications of insecticide for the 5% management regime, but only two applications of insecticide on the 5%/10% and 10% management regimes. HoCP85-845 and CP70-321 required one application of insecticide for the 5%, 5%/10%, and 10% management regimes.

First Ratoon Crop Year (2002)

The analysis of variance for the 2002 first ratoon crop indicated significant ($P \leq 0.05$) variety effects for the middle and upper portion of stalk for percent bored internodes, and total whole stalk percent bored internodes (Table 3.6). The results also indicated significant treatment thresholds effects for lower, middle, and upper portion of stalk percent bored internodes, and total whole stalk percent bored internodes. The analysis of variance indicated significant variety*treatment interaction effects for middle and upper portion of stalk percent bored internodes, and total whole stalk percent bored internodes.

Results for the 2002 first ratoon crop show significant variety effects for mean stalk weight, lower, middle, and upper portion of stalk fiber, and total whole stalk fiber (Table 3.7). In addition, significant variety effects for lower, middle, and upper portion of stalk were observed for TRS and total whole stalk TRS (Table 3.8). The results of the analysis of variance indicated significant treatment effects for lower, middle, and upper portion of stalk TRS, and total whole stalk TRS. The variety*treatment interaction was non-significant for all yield and quality components.

Table 3.6. Analysis of variance of fixed effects for the first ratoon sugarcane borer management threshold experiment involving four sugarcane varieties conducted at St. Gabriel, Louisiana in 2002.

Source	Lower portion of stalk percent bored internodes	Middle portion of stalk percent bored internodes	Upper portion of stalk percent bored internodes	Total whole stalk percent bored internodes
	---P-value---			
Variety	0.5438	0.0370	0.0189	0.0120
Treatment	<0.0001	<0.0001	<0.0001	<0.0001
Variety*Treatment	0.1780	<0.0001	0.0075	<0.0001
	---%---			
CV (%)	116.8	35.7	49.8	33.6

Table 3.7. Analysis of variance of fixed effects for the first ratoon sugarcane borer management threshold experiment involving four sugarcane varieties conducted at St. Gabriel, Louisiana in 2002.

Source	Mean stalk weight	Lower portion of stalk fiber	Middle portion of stalk fiber	Upper portion of stalk fiber	Total whole stalk fiber
	---P-value---				
Variety	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Treatment	0.5161	0.6565	0.1074	0.0875	0.1829
Variety*Treatment	0.5017	0.8891	0.9690	0.7516	0.9756
	---%---				
CV (%)	10.2	6.0	7.3	8.8	6.4

Table 3.8. Analysis of variance of fixed effects for the first ratoon sugarcane borer management threshold experiment involving four sugarcane varieties conducted at St. Gabriel, Louisiana in 2002.

Source	Lower portion of stalk TRS	Middle portion of stalk TRS	Upper portion of stalk TRS	Total whole stalk TRS	Cane yield (Weighed)	Sugar yield (Weighed)
	---P-value---					
Variety	<0.0001	<0.0001	0.0149	<0.0001	0.3893	0.0734
Treatment	0.0309	0.0020	0.0014	0.0013	0.7637	0.1735
Variety*Treatment	0.9634	0.8542	0.4091	0.8383	0.8279	0.6960
	---%---					
CV (%)	4.3	5.4	10.0	5.8	18.9	18.1

Stalk weight was significantly different between CP70-321 and HoCP85-845 with CP70-321 having a larger stalk size (Table 3.9). Stalk weights for both varieties were significantly different from that of LCP85-384 and HoCP91-555.

Total whole stalk fiber of HoCP85-845 was significantly higher from that of CP70-321, LCP85-384, and HoCP91-555. This difference is consistent with results obtained by the variety development program. No differences were detected between CP70-321 and LCP85-384 for TRS. HoCP85-845 TRS was statistically lower than that of HoCP91-555 and LCP85-384, which were not significantly different from each other.

Whole stalk TRS indicated a significant difference between the treated regimes (5%, 5%/10%, and 10%) and the non-treated regime (Table 3.10). A significant variety*treatment interaction for total percent bored internodes requires that means be reported by variety-management threshold.

Total percent bored internodes among the different variety-management threshold regimes (CP70-321 5%, 5%/10%, and 10%; HoCP85-845 5%, 5%/10%, and 10%; LCP85-384 5%, 5%/10%, and 10%; HoCP91-555 5%, 5%/10%, and 10%) were not significantly different (Table 3.11). Except for the untreated HoCP85-845, total percent bored internodes in all variety-management threshold regimes were significantly lower than that in the untreated regimes (P = <0.0001). However, the various management regimes required different numbers of insecticide applications to maintain sugarcane borer infestations below the designated thresholds. LCP85-384 and HoCP91-555 required two applications of insecticide during the growing season for the 5%, 5%/10%, and 10% management regimes. HoCP85-845 and CP70-321 both required one application of insecticide for the 5%, 5%/10%, and 10% management regimes.

Table 3.9. Variety means for the first ratoon study at St. Gabriel, Louisiana in 2002.

Variety	Mean stalk weight[a] (kg)	Total whole stalk fiber[a] (g/kg)	Total whole stalk TRS[a] (g/kg)
CP70-321	1.0a	124b	122bc
HoCP85-845	0.9b	156a	118c
HoCP91-555	0.7c	129b	130a
LCP85-384	0.7c	125b	129ab
P > F	<0.0001	<0.0001	<0.0001

[a]Means within a column followed by the same letter are not significantly different (P<0.05, Proc Mixed, Tukey-Kramer).

Table 3.10. Treatment means for the first ratoon study at St. Gabriel, Louisiana in 2002.

Management threshold regimes[a]	Total whole stalk TRS[b] (g/kg)
10%	128a
5%	127a
5%/10%	127a
Untreated	118b
P > F	0.0013

[a]Management threshold regimes are as follows: 5%: 5% sugarcane borer management threshold over entire season; 5%/10%: 5% sugarcane borer management threshold until Aug 1st and 10% sugarcane borer management threshold from Aug 1st through late season; 10: 10% sugarcane borer management threshold over entire season; Untreated: Never treated during the season.
[b]Means within a column followed by the same letter are not significantly different (P<0.05, Proc Mixed, Tukey-Kramer).

Table 3.11. Treatment by variety means for sugarcane borer management threshold study conducted at the St. Gabriel Sugar Research Station, St. Gabriel, Louisiana, 2002.

Variety	Management threshold regimes[a]	Insecticide application frequency	Total whole stalk percent bored internodes[b,c]
CP70-321	5%	2.0	6.2d
CP70-321	5%/10%	2.0	7.0cd
CP70-321	10%	1.0	12.8cd
CP70-321	Untreated	--	27.4b
LCP85-384	5%	2.0	5.4d
LCP85-384	10%	2.0	7.2cd
LCP85-384	5%/10%	2.0	6.1d
LCP85-384	Untreated	--	41.3a
HoCP91-555	5%	2.0	6.2d
HoCP91-555	5%/10%	2.0	8.9cd
HoCP91-555	10%	2.0	9.7cd
HoCP91-555	Untreated	--	41.2a
HoCP85-845	5%	1.0	7.0cd
HoCP85-845	5%/10%	1.0	10.6cd
HoCP85-845	10%	1.0	7.9cd
HoCP85-845	Untreated	--	18.6bc
P > F			<0.0001

[a]Management threshold regimes are as follows: 5%: 5% sugarcane borer management threshold over entire season; 5%/10%: 5% sugarcane borer management threshold until Aug 1st and 10% sugarcane borer management threshold from Aug 1st through late season; 10%: 10% sugarcane borer management threshold over entire season; Untreated: Never treated during the season.

[b]25 stalks per plot were harvested on Dec. 1, 2002 and evaluated for bored internodes.

[c]Means within a column followed by the same letter are not significantly different ($P<0.05$, Proc Mixed, Tukey-Kramer).

Discussion

Varieties play an important role in determining grower profitability and ultimate survival at current market prices. LCP85-384, which represents 88% of the commercially grown sugarcane varieties in the Louisiana sugarcane industry, is a variety that has improved the grower's profitability. With higher input costs and decreasing profit margins, increasing higher yielding varieties on a farm has become the key to survival for many growers. Varieties like CP70-321, once the leading variety for the Louisiana sugarcane industry, can no longer be grown profitably. Planting a variety based on sugarcane borer susceptibility is probably a low priority by a grower, when environmentally sensitive areas (i.e. schools, homes, lakes, etc.) are not a factor. Growers strive to find that balance between treating with insecticides to maintain sugarcane borer infestations below an economic injury level and paying for the costs of the applications. Proper budgeting for at least two insecticide applications per hectare is strongly encouraged when growers plant sugarcane borer susceptible varieties on their farms and budgeting for one application for resistant varieties.

HoCP85-845 has demonstrated in past studies to be a variety that can be used when management and environmental conditions would not allow insecticide applications (Bessin et al. 1990a, b). Using this variety in environmentally sensitive areas would permit the grower to take advantage of the resistance aspects of this variety and help minimize loss, compared to the other varieties that would suffer significant reduction in sugar per hectare when left untreated (White 2000). A resistant variety such as HoCP85-845 can also have a major impact on an area-wide basis by decreasing moth production per hectare (Bessin et al. 1990a, b). In support of this previous work, the untreated variety-management threshold regime for HoCP85-845 was not significantly different for percent bored internodes from the treated regimes for HoCP85-845. Thus, the utility of varietal resistance, with a variety such as HoCP85-845, was shown here.

In past studies, CP70-321 has demonstrated the potential for use in traditionally low to moderate infestation areas where conditions would be inappropriate for insecticide use. Growers who have acreage of CP70-321 should be aware of the late-season damage that tends to occur under high levels of sugarcane borer infestations (White 2000). CP70-321 has high levels of antibiosis (young borers have difficulty entering the stalk), but a low level of tolerance once the larvae have entered the stalk and suffers significant reduction in sugar (White 2000). In this study, the untreated variety-management threshold regime for CP70-321 was significantly different from the treated regimes for CP70-321 for percent bored internodes.

This study also emphasizes that LCP85-384 and HoCP91-555 should be monitored closely on weekly intervals due to the susceptibility to the sugarcane borer. A properly timed application is key for the effective control of the sugarcane borer. For instance in 2001, infestation levels during the first week of August were unavailable and insecticide applications were needed. When infestation levels were taken during the second week of August, the infestations were considerably higher than the threshold. Two weeks of rainfall further delayed the insecticide application. An application was finally made on the 24th of August. The HoCP91-555 10% management threshold was mistakenly not treated on the 24th of August resulting in an inflated end-of-season percent-bored internodes value of 16.4% (Table 3.5). A follow-up application on the 5th of September was required in order to control remaining insects from the previous application. As a result, three applications on some treatments were required to maintain sugarcane borer infestations at the desired treatment regime level. The results in 2001 support the work of White (2000) who showed that the highly susceptible variety HoCP91-555 required insecticide treatment approximately 10 days earlier than LCP85-384. The results in 2001 were similar to the conclusion of White (2000) when HoCP91-555 was treated 10 days before the other varieties included in this experiment. In 2002, HoCP91-555 attained insecticide treatment status similar to CP70-321 and LCP85-384 and one week earlier than HoCP85-845.

Plots that were maintained sugarcane borer free by spraying each week might have improved yield reduction comparisons among treatments (Williams 1969) and may have allowed for a better separation of the treatments. The most important information resulting from this study is the demonstration of the value of treated vs. non-treated regimes (Table 3.12). Using this data, a grower could justify two applications of insecticides plus the cost of the consultant ($16.18 for two applications plus $1.62 for consulting fee per hectare) for the control of the sugarcane borer versus not treating and incurring a decline in TRS at a cane yield of 69.5 metric tons per hectare.

This work further demonstrates the value of treating with insecticides to control sugarcane borer infestations and maintaining end-of-season percent bored internodes below an economic injury level (White and Hensley 1987, Hensley 1971, Hensley and Long 1969).

Table 3.12. Comparison of treated management threshold regimes versus non-treated regime for sugarcane borer management threshold study conducted at the St. Gabriel Sugar Research Station, St. Gabriel, Louisiana, 2002.

Management threshold regimes[a]	Total whole stalk TRS[b] (g/kg)	Mean weighed cane yield for entire test used for standard comparison (mt/h)	Growers share of gross income per hectare[c]	Marginal change in gross income from treatment
Treated	127	69.5	$1900	$113
Untreated	118	69.5	$1787	--

[a]Management threshold regimes are as follows: Treated: Average of 5% Sugarcane borer management threshold over entire season, 5% Sugarcane borer management threshold until Aug 1st and 10% Sugarcane borer management threshold from Aug 1st through late season, and 10% Sugarcane borer management threshold over entire season; Untreated: Never treated during the season.
[b]Average of TRS for treated regimes (Table 3.10).
[c]Growers share of gross income per acre is considered to be around 48.8% with the other 51.2% going to the mill and landowner based on a sugar price of 0.441 cents per kilogram.

CHAPTER 4

SUMMARY AND CONCLUSIONS

Summary

No significant correlations were detected in the survey of the Louisiana sugarcane industry in 2000 and 2001 between seasonal rainfall events and insecticide application frequency, spring deadhearts, or end-of-season bored internodes. However, in the areas that had early rainfall and continued to receive frequent rains throughout the season, a higher use rate of insecticide was used and frequently a higher percentage of end-of-season bored internodes were encountered. The information provided by the survey concerning the association between amounts of rainfall and sugarcane borer infestations throughout the season seemed to be accurate based upon empirical data gathered by the author during the 2003 sugarcane production season. The industry experienced early rains in April and May, which was followed by constant rainfall in the production months of June, July, and August. Many producers averaged between one and two applications, and a few growers made three applications.

In the sugarcane borer management study, results from the plant cane crop (2001) and from the first ratoon crop (2002) showed no differences among different variety-management threshold strategies, except for significantly lower percent bored internodes for the treated regimes compared to the non-treated regimes. However, the threshold management regimes varied insecticide application frequency to maintain sugarcane borer infestations below the designated thresholds.

TRS was significantly different between the treated regimes (5%, 5%/10%, and 10%) and the non-treated regime, and illustrates the economic value of treating sugarcane borer infestations with insecticides. According to this study, a grower could justify two applications of insecticides plus the cost of the consultant for control of the sugarcane borer and have around four dollars/ha remaining in the budget versus not treating and suffering losses due to a decline in TRS at a cane yield of 69.5 metric tons per hectare.

Conclusions

The information derived from this research can be useful to a consultant or grower when deciding when to apply insecticide based upon a sugarcane borer infestation level. However, many other factors must be considered other than an infestation level (threshold) at a particular time in the growing season, such as rainfall and varietal resistance. Ultimately, it may not be practical for a specific threshold to be determined for each variety, and the process is probably much too complex for a single value to summarize the many factors needed to determine the need to apply insecticide (White 2000). However, the data suggest not deviating much beyond the recommended 5% threshold when managing highly susceptible varieties such as HoCP91-555. The decision to apply insecticide will continue to be based on the experience and judgment of the consultant or grower. Grower expectations and goals can be different. The grower's financial situation, environmental factors such as rainfall, the variety, the crop year, the stage of the crop and the time of the season, yield expectation, and the amount of time it takes for the applicator to apply insecticide to the field are important considerations. Key to effective IPM is developing an infestation history of the farm thereby gaining experience of where the problem fields are located. No two fields, farms, areas or years are alike. The grower or consultant must be very attentive to proper scouting of fields and timing of insecticides. This study showed the importance of rainfall as a contributing factor for an increase in sugarcane borer levels and the role of resistant and highly susceptible varieties in a management strategy.

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APPENDIX A: 2000 SUGARCANE INDUSTRY SURVEY SAS OUTPUT

Obs	FLD	AREA	REP	BORE
1	1	T	1	2.3
2	1	T	2	0.9
3	2	T	1	0.3
4	2	T	2	0.0
5	1	T	1	0.3
6	1	T	2	0.4
7	2	T	1	1.2
8	2	T	2	2.1
9	1	T	1	0.6
10	1	T	2	0.3
11	2	T	1	1.2
12	2	T	2	3.4
13	1	T	1	0.3
14	1	T	2	0.0
15	2	T	1	1.2
16	2	T	2	0.0
17	1	T	1	1.6
18	1	T	2	0.0
19	2	T	1	0.0
20	2	T	2	0.0
21	1	T	1	1.1
22	1	T	2	0.0
23	2	T	1	0.0
24	2	T	2	0.0
25	1	T	1	4.6
26	1	T	2	5.0
27	2	T	1	0.0
28	2	T	2	0.0
29	1	T	1	4.1
30	1	T	2	1.4
31	2	T	1	1.5
32	2	T	2	0.0
33	1	V	1	0.4
34	1	V	2	0.0
35	2	V	1	0.0
36	2	V	2	0.0
37	1	V	1	0.7
38	1	V	2	0.3
39	2	V	1	0.4
40	2	V	2	0.7
41	1	V	1	0.5
42	1	V	2	0.0
43	2	V	1	0.0
44	2	V	2	0.3
45	1	V	1	1.4
46	1	V	2	0.0
47	2	V	1	0.5
48	2	V	2	0.0
49	1	V	1	1.6
50	1	V	2	0.0
51	2	V	1	6.2
52	2	V	2	3.2
53	1	V	1	1.6
54	1	V	2	5.6
55	2	V	1	3.2

56	2	V	2	1.6
57	1	V	1	0.0
58	1	V	2	3.2
59	2	V	1	0.0
60	2	V	2	4.0
61	1	V	1	0.0
62	1	V	2	1.6
63	2	V	1	0.7
64	2	V	2	2.3
65	1	LL	1	4.8
66	1	LL	2	7.3
67	2	LL	1	4.2
68	2	LL	2	3.1
69	1	LL	1	1.2
70	1	LL	2	0.5
71	2	LL	1	1.5
72	2	LL	2	1.0
73	1	LL	1	1.0
74	1	LL	2	0.6
75	2	LL	1	0.9
76	2	LL	2	1.7
77	1	LL	1	0.3
78	1	LL	2	0.9
79	2	LL	1	0.3
80	2	LL	2	0.6
81	1	LL	1	4.9
82	1	LL	2	2.1
83	2	LL	1	2.1
84	2	LL	2	4.9
85	1	LL	1	0.3
86	1	LL	2	0.7
87	2	LL	1	0.0
88	2	LL	2	0.0
89	1	LL	1	8.3
90	1	LL	2	4.6
91	2	LL	1	4.6
92	2	LL	2	8.3
93	1	LL	1	1.5
94	1	LL	2	3.9
95	2	LL	1	0.0
96	2	LL	2	0.0
97	1	UR	1	6.3
98	1	UR	2	5.1
99	2	UR	1	4.1
100	2	UR	2	0.8
101	1	UR	1	0.5
102	1	UR	2	1.7
103	2	UR	1	1.1
104	2	UR	2	3.3
105	1	UR	1	9.7
106	1	UR	2	19.2
107	2	UR	1	0.5
108	2	UR	2	2.9
109	1	UR	1	0.0
110	1	UR	2	0.0
111	2	UR	1	0.0
112	2	UR	2	2.1
113	1	UR	1	1.2

114	1	UR	2	8.3
115	2	UR	1	0.7
116	2	UR	2	1.3
117	1	UR	1	2.1
118	1	UR	2	5.5
119	2	UR	1	0.8
120	2	UR	2	0.0
121	1	UR	1	0.7
122	1	UR	2	0.9
123	2	UR	1	0.7
124	2	UR	2	1.3
125	1	UR	1	0.0
126	1	UR	2	0.0
127	2	UR	1	1.2
128	2	UR	2	1.4
129	1	UL	1	6.2
130	1	UL	2	5.4
131	2	UL	1	2.8
132	2	UL	2	2.0
133	1	UL	1	1.1
134	1	UL	2	1.7
135	2	UL	1	1.1
136	2	UL	2	0.6
137	1	UL	1	2.3
138	1	UL	2	2.9
139	2	UL	1	0.9
140	2	UL	2	2.8
141	1	UL	1	0.0
142	1	UL	2	0.4
143	2	UL	1	2.1
144	2	UL	2	0.0
145	1	UL	1	2.6
146	1	UL	2	7.5
147	2	UL	1	4.2
148	2	UL	2	3.7
149	1	UL	1	0.9
150	1	UL	2	0.0
151	2	UL	1	2.3
152	2	UL	2	1.4
153	1	UL	1	11.1
154	1	UL	2	1.3
155	2	UL	1	4.2
156	2	UL	2	3.7
157	1	UL	1	0.9
158	1	UL	2	0.4
159	2	UL	1	0.6
160	2	UL	2	1.0
161	1	C	1	2.3
162	1	C	2	2.8
163	2	C	1	3.5
164	2	C	2	2.6
165	1	C	1	5.4
166	1	C	2	7.0
167	2	C	1	3.7
168	2	C	2	6.1
169	1	C	1	2.0
170	1	C	2	3.0
171	2	C	1	2.1

172	2	C	2	0.7
173	1	C	1	1.5
174	1	C	2	0.5
175	2	C	1	2.8
176	2	C	2	0.9
177	1	C	1	9.6
178	1	C	2	0.9
179	2	C	1	1.4
180	2	C	2	9.8
181	1	C	1	0.0
182	1	C	2	0.6
183	2	C	1	0.0
184	2	C	2	1.7
185	1	C	1	21.3
186	1	C	2	18.6
187	2	C	1	3.2
188	2	C	2	3.2
189	1	C	1	4.6
190	1	C	2	2.0
191	2	C	1	2.9
192	2	C	2	2.6
193	1	LR	1	1.1
194	1	LR	2	0.0
195	2	LR	1	1.3
196	2	LR	2	3.8
197	1	LR	1	2.5
198	1	LR	2	0.0
199	2	LR	1	0.0
200	2	LR	2	0.0
201	1	LR	1	0.5
202	1	LR	2	0.0
203	2	LR	1	0.0
204	2	LR	2	0.0
205	1	LR	1	0.5
206	1	LR	2	0.9
207	2	LR	1	0.9
208	2	LR	2	0.3
209	1	LR	1	0.8
210	1	LR	2	0.0
211	2	LR	1	2.5
212	2	LR	2	1.1
213	1	LR	1	0.3
214	1	LR	2	1.2
215	2	LR	1	0.0
216	2	LR	2	1.0
217	1	LR	1	0.5
218	1	LR	2	0.0
219	2	LR	1	0.0
220	2	LR	2	0.0
221	1	LR	1	0.6
222	1	LR	2	1.1
223	2	LR	1	0.7
224	2	LR	2	1.9
225	1	SW	1	3.1
226	1	SW	2	6.8
227	2	SW	1	6.8
228	2	SW	2	3.1
229	1	SW	1	1.8

```
230     1      SW      2      3.7
231     2      SW      1      3.7
232     2      SW      2      1.8
233     1      SW      1      2.1
234     1      SW      2      0.0
235     2      SW      1      2.2
236     2      SW      2      0.4
237     1      SW      1      1.8
238     1      SW      2      3.7
239     2      SW      1      3.7
240     2      SW      2      1.8

The Mixed Procedure
                  Model Information
Data Set                     WORK.SUGAR
Dependent Variable           BORE
Covariance Structure         Variance Components
Estimation Method            Type 3
Residual Variance Method     Factor
Fixed Effects SE Method      Model-Based
Degrees of Freedom Method    Satterthwaite
             Class Level Information
Class    Levels    Values
FLD           2    1 2
AREA          8    C LL LR SW T UL UR V
REP           2    1 2
            Dimensions
Covariance Parameters            2
Columns in X                    27
Columns in Z                     2
Subjects                         1
Max Obs Per Subject            240
Observations Used              240
Observations Not Used            0
Total Observations             240
                         Type 3 Analysis of Variance
                        Sum of
Source        DF       Squares   Mean Square  Expected Mean Square
FLD            1     32.133472     32.133472  Var(Residual) + Q(FLD,FLD*AREA)
                        Type 3 Analysis of Variance
                                                  Error
Source    Error Term                                 DF    F Value    Pr > F
FLD       MS(Residual)                              223       4.23    0.0409
The SAS System                                                               8
The Mixed Procedure
                         Type 3 Analysis of Variance
                        Sum of
Source        DF       Squares   Mean Square  Expected Mean Square
AREA           7    262.774833     37.539262  Var(Residual) + Q(AREA,FLD*AREA)
FLD*AREA       7     59.662333      8.523190  Var(Residual) + Q(FLD*AREA)
REP            1      0.477042      0.477042  Var(Residual) + 120 Var(REP)
Residual     223   1693.986708      7.596353  Var(Residual)
                        Type 3 Analysis of Variance
                                                  Error
Source    Error Term                                 DF    F Value    Pr > F
AREA      MS(Residual)                              223       4.94    <.0001
FLD*AREA  MS(Residual)                              223       1.12    0.3501
REP       MS(Residual)                              223       0.06    0.8024
```

```
Residual  .                                           .        .       .
Covariance Parameter
      Estimates
Cov Parm     Estimate
REP          -0.05933
Residual       7.5964
           Fit Statistics
-2 Res Log Likelihood          1130.1
AIC (smaller is better)        1134.1
AICC (smaller is better)       1134.1
BIC (smaller is better)        1131.5
        Type 3 Tests of Fixed Effects
              Num     Den
Effect         DF      DF    F Value    Pr > F

FLD             1     223       4.23    0.0409
AREA            7     223       4.94    <.0001
FLD*AREA        7     223       1.12    0.3501
Effect=FLD   Method=Tukey-Kramer(P<0.05)   Set=1
                                  Standard    Letter
Obs    FLD    AREA    Estimate     Error      Group
  1     1               2.5523      0.1926      A
  2     2               1.8008      0.1926      B
Effect=AREA   Method=Tukey-Kramer(P<0.05)   Set=2
                                  Standard    Letter
Obs    FLD    AREA    Estimate     Error      Group
  3            C        4.0406      0.4558      A
  4            SW       2.9063      0.6672      AB
  5            UR       2.6063      0.4558      AB
  6            UL       2.4406      0.4558      AB
  7            LL       2.3781      0.4558      AB
  8            V        1.2500      0.4558      B
  9            T        1.0562      0.4558      B
 10            LR       0.7344      0.4558      B
Effect=FLD*AREA   Method=Tukey-Kramer(P<0.05)   Set=3
                                  Standard    Letter
Obs    FLD    AREA    Estimate     Error      Group
 11     1      C        5.1312      0.6672      A
 12     1      UR       3.8250      0.6672      AB
 13     2      C        2.9500      0.6672      AB
 14     2      SW       2.9375      0.9591      AB
 15     1      SW       2.8750      0.9591      AB
 16     1      UL       2.7937      0.6672      AB
 17     1      LL       2.6812      0.6672      AB
 18     2      UL       2.0875      0.6672      AB
 19     2      LL       2.0750      0.6672      AB
 20     2      V        1.4437      0.6672      B
 21     1      T        1.4312      0.6672      B
 22     2      UR       1.3875      0.6672      B
 23     1      V        1.0563      0.6672      B
 24     2      LR       0.8437      0.6672      B
 25     2      T        0.6813      0.6672      B
 26     1      LR       0.6250      0.6672      B
```

APPENDIX B: 2001 SUGARCANE INDUSTRY SURVEY SAS OUTPUT

Obs	FLD	AREA	REP	BORE
1	1	C	1	0.8
2	1	C	2	1.2
3	2	C	1	0.0
4	2	C	2	0.4
5	1	C	1	0.5
6	1	C	2	2.1
7	2	C	1	0.0
8	2	C	2	1.2
9	1	C	1	1.3
10	1	C	2	1.0
11	2	C	1	4.6
12	2	C	2	1.6
13	1	C	1	1.8
14	1	C	2	2.0
15	2	C	1	1.5
16	2	C	2	2.3
17	1	C	1	1.7
18	1	C	2	0.0
19	2	C	1	3.8
20	2	C	2	0.0
21	1	C	1	0.7
22	1	C	2	0.7
23	2	C	1	2.4
24	2	C	2	8.4
25	1	UR	1	0.0
26	1	UR	2	0.0
27	2	UR	1	1.9
28	2	UR	2	0.8
29	1	UR	1	0.4
30	1	UR	2	1.6
31	2	UR	1	3.5
32	2	UR	2	2.1
33	1	UR	1	4.0
34	1	UR	2	4.4
35	2	UR	1	7.5
36	2	UR	2	7.0
37	1	UR	1	0.8
38	1	UR	2	2.0
39	2	UR	1	11.9
40	2	UR	2	32.7
41	1	UR	1	4.0
42	1	UR	2	14.2
43	2	UR	1	4.4
44	2	UR	2	2.1
45	1	UR	1	4.5
46	1	UR	2	4.3
47	2	UR	1	16.8
48	2	UR	2	19.5
49	1	UL	1	0.9
50	1	UL	2	1.7
51	2	UL	1	2.5
52	2	UL	2	2.9
53	1	UL	1	1.5
54	1	UL	2	0.3
55	2	UL	1	1.0

56	2	UL	2	0.5
57	1	UL	1	4.4
58	1	UL	2	6.8
59	2	UL	1	2.5
60	2	UL	2	3.5
61	1	UL	1	1.0
62	1	UL	2	3.2
63	2	UL	1	2.3
64	2	UL	2	1.7
65	1	LR	1	12.2
66	1	LR	2	10.6
67	2	LR	1	7.7
68	2	LR	2	2.8
69	1	LR	1	7.8
70	1	LR	2	3.2
71	2	LR	1	2.2
72	2	LR	2	6.2
73	1	LR	1	4.6
74	1	LR	2	2.3
75	2	LR	1	3.4
76	2	LR	2	2.9
77	1	LR	1	2.3
78	1	LR	2	4.5
79	2	LR	1	2.4
80	2	LR	2	1.6
81	1	LR	1	2.2
82	1	LR	2	1.8
83	2	LR	1	1.5
84	2	LR	2	1.6
85	1	LR	1	1.3
86	1	LR	2	2.5
87	2	LR	1	1.5
88	2	LR	2	1.1
89	1	T	1	2.3
90	1	T	2	1.3
91	2	T	1	2.3
92	2	T	2	3.2
93	1	T	1	0.6
94	1	T	2	6.3
95	2	T	1	1.3
96	2	T	2	2.2
97	1	T	1	2.0
98	1	T	2	2.4
99	2	T	1	0.6
100	2	T	2	0.9
101	1	T	1	2.3
102	1	T	2	2.2
103	2	T	1	3.2
104	2	T	2	0.5
105	1	T	1	0.8
106	1	T	2	0.8
107	2	T	1	2.1
108	2	T	2	4.2
109	1	T	1	2.3
110	1	T	2	1.2
111	2	T	1	2.2
112	2	T	2	1.1
113	1	LL	1	2.7

114	1	LL	2	1.7
115	2	LL	1	0.6
116	2	LL	2	1.0
117	1	LL	1	5.9
118	1	LL	2	1.6
119	2	LL	1	3.2
120	2	LL	2	0.5
121	1	LL	1	3.6
122	1	LL	2	2.4
123	2	LL	1	0.5
124	2	LL	2	0.0
125	1	LL	1	1.3
126	1	LL	2	1.1
127	2	LL	1	3.5
128	2	LL	2	2.5
129	1	V	1	9.4
130	1	V	2	16.0
131	2	V	1	10.2
132	2	V	2	9.0
133	1	V	1	3.2
134	1	V	2	7.9
135	2	V	1	2.9
136	2	V	2	6.0
137	1	V	1	16.7
138	1	V	2	10.2
139	2	V	1	9.5
140	2	V	2	11.2
141	1	V	1	3.4
142	1	V	2	2.7
143	2	V	1	2.6
144	2	V	2	2.7
145	1	V	1	4.4
146	1	V	2	12.5
147	2	V	1	0.5
148	2	V	2	0.5
149	1	V	1	2.6
150	1	V	2	5.9
151	2	V	1	1.4
152	2	V	2	1.2
153	1	V	1	3.8
154	1	V	2	0.9
155	2	V	1	4.4
156	2	V	2	1.2
157	1	V	1	2.1
158	1	V	2	0.5
159	2	V	1	3.4
160	2	V	2	6.6
161	1	SW	1	4.2
162	1	SW	2	3.8
163	2	SW	1	2.0
164	2	SW	2	9.8
165	1	SW	1	2.0
166	1	SW	2	1.3
167	2	SW	1	1.0
168	2	SW	2	2.2
169	1	SW	1	2.6
170	1	SW	2	0.6
171	2	SW	1	0.6

```
172     2      SW      2      1.3
173     1      SW      1      2.5
174     1      SW      2      3.2
175     2      SW      1      0.7
176     2      SW      2      1.3

The Mixed Procedure
                  Model Information
Data Set                     WORK.SUGAR
Dependent Variable           BORE
Covariance Structure         Variance Components
Estimation Method            Type 3
Residual Variance Method     Factor
Fixed Effects SE Method      Model-Based
Degrees of Freedom Method    Satterthwaite
             Class Level Information
Class    Levels    Values
FLD           2    1 2
AREA          8    C LL LR SW T UL UR V
REP           2    1 2
            Dimensions
Covariance Parameters             2
Columns in X                     27
Columns in Z                      2
Subjects                          1
Max Obs Per Subject             176
Observations Used               176
Observations Not Used             0
Total Observations              176
                         Type 3 Analysis of Variance
                        Sum of
Source        DF       Squares   Mean Square  Expected Mean Square
FLD            1      1.906895      1.906895  Var(Residual) + Q(FLD,FLD*AREA)
                        Type 3 Analysis of Variance
                                                  Error
Source    Error Term                                 DF    F Value    Pr > F
FLD       MS(Residual)                              159       0.14    0.7122
The Mixed Procedure
                         Type 3 Analysis of Variance
                        Sum of
Source        DF       Squares   Mean Square  Expected Mean Square
AREA           7    521.840653     74.548665  Var(Residual) + Q(AREA,FLD*AREA)
FLD*AREA       7    256.975881     36.710840  Var(Residual) + Q(FLD*AREA)
REP            1     11.762784     11.762784  Var(Residual) + 88 Var(REP)
Residual     159   2219.247841     13.957534  Var(Residual)
                        Type 3 Analysis of Variance
                                                  Error
Source    Error Term                                 DF    F Value    Pr > F
AREA      MS(Residual)                              159       5.34    <.0001
FLD*AREA  MS(Residual)                              159       2.63    0.0134
REP       MS(Residual)                              159       0.84    0.3600
Residual  .                                           .          .       .
Covariance Parameter
      Estimates
Cov Parm     Estimate
REP          -0.02494
Residual      13.9575
           Fit Statistics
```

-2 Res Log Likelihood	913.6
AIC (smaller is better)	917.6
AICC (smaller is better)	917.6
BIC (smaller is better)	914.9

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
FLD	1	159	0.14	0.7122
AREA	7	159	5.34	<.0001
FLD*AREA	7	159	2.63	0.0134

Effect=FLD   Method=Tukey-Kramer(P<0.05)   Set=1

Obs	FLD	AREA	Estimate	Standard Error	Letter Group
1	2		3.3487	0.3945	A
2	1		3.1344	0.3945	A

Effect=AREA   Method=Tukey-Kramer(P<0.05)   Set=2

Obs	FLD	AREA	Estimate	Standard Error	Letter Group
3		UR	6.2667	0.7544	A
4		V	5.4844	0.6509	AB
5		LR	3.7583	0.7544	ABC
6		SW	2.4438	0.9273	BC
7		UL	2.2938	0.9273	BC
8		T	2.0125	0.7544	C
9		LL	2.0063	0.9273	BC
10		C	1.6667	0.7544	C

Effect=FLD*AREA   Method=Tukey-Kramer(P<0.05)   Set=3

Obs	FLD	AREA	Estimate	Standard Error	Letter Group
11	2	UR	9.1833	1.0727	A
12	1	V	6.3875	0.9273	AB
13	1	LR	4.6083	1.0727	ABC
14	2	V	4.5813	0.9273	ABC
15	1	UR	3.3500	1.0727	BC
16	2	LR	2.9083	1.0727	BC
17	1	LL	2.5375	1.3161	BC
18	1	SW	2.5250	1.3161	BC
19	1	UL	2.4750	1.3161	BC
20	2	SW	2.3625	1.3161	BC
21	2	C	2.1833	1.0727	BC
22	2	UL	2.1125	1.3161	BC
23	1	T	2.0417	1.0727	BC
24	2	T	1.9833	1.0727	BC
25	2	LL	1.4750	1.3161	BC
26	1	C	1.1500	1.0727	C

APPENDIX C: 2000 AND 2001 SUGARCANE INDUSTRY SURVEY SAS PROGRAM

```
DATA SUGAR; INFILE CARDS MISSOVER;
INPUT FLD$ AREA$ REP BORE EST;
CARDS;
;
PROC PRINT DATA=SUGAR;
RUN;
PROC MIXED data=SUGAR method=type3;
CLASSES FLD AREA REP;
MODEL BORE = fld AREA fld*area    /HTYPE=3 DDFM = SATTERTHWAITE OUTP=SUGAR2;
RANDOM REP;
LSMEANS fld AREA fld*area    / PDIFF ADJUST = TUKEY;
ODS OUTPUT DIFFS=PPP;
ODS OUTPUT LSMEANS=MMM;
ODS LISTING EXCLUDE DIFFS;
ODS LISTING EXCLUDE LSMEANS;
RUN;
%INCLUDE 'C:\PDMIX800.SAS';
%PDMIX800 (PPP, MMM, ALPHA=0.05, SORT=YES);
RUN;
QUIT;
```

APPENDIX D: 2001 SUGARCANE ECONOMIC THRESHOLD SAS OUTPUT

Obs	NUM	YEAR	VAR	TRT	REP	FIB	TRS	BOR1	BOR2	BOR3	LBS	SW	TONS	BOR
1	1	2001	321	A	1	15.7	207.8	0.0	0.7	4.8	11032	3.29	53	5.5
2	1	2001	321	A	2	16.6	206.5	0.0	1.1	4.6	10213	3.19	49	5.7
3	1	2001	321	A	3	23.2	196.6	0.2	2.8	4.1	11300	3.05	57	7.1
4	1	2001	321	A	4	13.1	218.0	0.0	1.2	2.1	10551	2.93	48	3.3
5	2	2001	321	B	1	16.9	198.0	0.7	3.9	4.8	10332	2.89	52	9.4
6	2	2001	321	B	2	12.3	211.7	0.0	3.2	4.5	11911	2.81	56	7.7
7	2	2001	321	B	3	19.7	160.6	0.2	3.7	4.3	11854	2.92	74	8.2
8	2	2001	321	B	4	14.8	193.4	0.0	2.7	4.5	11584	3.17	60	7.2
9	3	2001	321	C	1	16.8	204.2	1.3	8.7	4.9	9451	3.09	46	14.9
10	3	2001	321	C	2	11.2	223.4	0.4	3.9	8.7	11556	3.17	52	13.0
11	3	2001	321	C	3	17.0	194.3	0.2	9.6	3.5	14459	3.07	74	13.3
12	3	2001	321	C	4	11.1	240.4	2.0	8.4	6.9	13672	2.87	57	17.3
13	4	2001	321	D	1	18.1	200.9	1.1	9.0	4.2	9207	3.05	46	14.3
14	4	2001	321	D	2	13.3	238.1	0.2	1.3	3.0	12857	3.09	54	4.5
15	4	2001	321	D	3	20.1	185.9	0.2	1.6	2.5	11134	3.03	60	4.3
16	4	2001	321	D	4	12.4	253.5	0.7	2.3	2.1	13496	3.07	53	5.1
17	5	2001	384	A	1	13.7	221.9	0.0	2.0	1.6	10471	2.33	47	3.6
18	5	2001	384	A	2	16.8	216.4	0.9	2.5	3.9	9132	2.28	42	7.3
19	5	2001	384	A	3	13.8	222.5	0.7	0.2	5.0	10769	2.21	48	5.9
20	5	2001	384	A	4	11.4	206.5	0.5	0.8	2.2	11369	1.78	55	3.5
21	6	2001	384	B	1	13.9	236.4	0.7	3.0	2.3	10834	2.01	46	6.0
22	6	2001	384	B	2	7.3	204.3	0.8	8.9	4.3	10104	1.63	49	14.0
23	6	2001	384	B	3	21.9	190.0	0.9	3.2	3.1	10346	1.93	54	7.2
24	6	2001	384	B	4	18.3	201.5	0.0	2.2	2.2	9631	1.89	48	4.4
25	7	2001	384	C	1	13.0	213.4	2.5	11.8	8.8	9683	2.19	45	23.1
26	7	2001	384	C	2	18.9	189.9	0.7	9.9	9.6	9565	2.29	50	20.2
27	7	2001	384	C	3	19.8	190.4	0.7	7.7	10.9	9331	2.35	49	19.3
28	7	2001	384	C	4	13.1	196.5	0.0	6.9	8.7	11294	2.00	57	15.6
29	8	2001	384	D	1	13.4	218.5	1.9	16.0	7.8	11699	2.03	54	25.7
30	8	2001	384	D	2	11.6	209.1	0.8	7.0	1.3	12904	1.80	62	9.1
31	8	2001	384	D	3	11.2	230.9	2.3	10.6	3.2	13830	2.59	60	16.1
32	8	2001	384	D	4	14.8	206.0	0.0	2.2	1.4	7976	1.99	39	3.6
33	9	2001	555	A	1	18.6	201.0	0.0	0.7	3.7	9759	2.07	49	4.4
34	9	2001	555	A	2	18.5	208.0	1.8	3.7	3.2	10004	2.29	48	8.7
35	9	2001	555	A	3	15.6	146.1	0.0	1.0	3.9	8662	2.41	59	4.9
36	9	2001	555	A	4	12.2	195.5	0.0	0.8	1.3	11000	2.28	56	2.1
37	10	2001	555	B	1	13.3	220.6	0.0	1.7	3.0	12412	2.16	56	4.7
38	10	2001	555	B	2	12.9	193.9	1.5	2.1	1.3	11174	2.29	58	4.9
39	10	2001	555	B	3	14.5	198.1	0.2	5.8	1.6	16180	2.37	82	7.6
40	10	2001	555	B	4	18.3	186.2	0.0	2.5	1.5	9801	2.45	53	4.0
41	11	2001	555	C	1	17.0	179.0	1.3	12.8	16.3	8366	2.00	47	30.4
42	11	2001	555	C	2	12.3	196.4	2.2	12.6	18.5	10783	2.47	55	33.3
43	11	2001	555	C	3	11.0	197.3	0.0	18.5	10.3	10743	2.00	54	28.8
44	11	2001	555	C	4	17.7	191.2	4.0	16.4	7.4	9601	2.00	50	27.8
45	12	2001	555	D	1	11.9	205.5	2.6	12.3	3.2	9325	2.26	45	18.1
46	12	2001	555	D	2	15.0	210.4	1.3	10.3	3.2	10788	2.19	51	14.8
47	12	2001	555	D	3	17.1	186.9	1.7	12.3	3.2	13004	2.30	70	17.2
48	12	2001	555	D	4	17.9	165.7	1.2	10.8	3.4	9524	2.66	57	15.4
49	13	2001	845	A	1	9.2	251.8	0.0	2.9	2.0	10511	2.51	42	4.9
50	13	2001	845	A	2	14.4	227.4	0.2	2.4	1.4	10525	2.57	46	4.0
51	13	2001	845	A	3	8.1	236.2	0.0	2.1	1.6	17291	2.98	73	3.7
52	13	2001	845	A	4	15.4	213.2	0.0	2.6	1.8	10964	2.47	51	4.4
53	14	2001	845	B	1	20.1	209.0	0.4	1.7	1.0	10621	2.52	51	3.1
54	14	2001	845	B	2	11.9	239.6	0.7	1.4	1.7	11850	2.73	49	3.8
55	14	2001	845	B	3	15.8	190.2	1.5	6.5	1.9	11392	2.85	60	9.9

```
56 14  2001 845  B   4  17.4 194.1  1.0  2.4  1.5 10921 2.47  56   4.9
57 15  2001 845  C   1  18.5 197.7  0.6  4.2  3.0  9240 2.55  47   7.8
58 15  2001 845  C   2  17.2 185.9  2.7  7.7  7.5  9026 3.08  49  17.9
59 15  2001 845  C   3  12.9 237.7  0.8  3.0  2.5 12511 2.63  53   6.3
60 15  2001 845  C   4  12.5 208.5  0.2  3.4  6.2  9965 2.65  48   9.8
61 16  2001 845  D   1  17.2 205.8  1.7  3.2  1.7  9151 2.25  44   6.6
62 16  2001 845  D   2  17.6 156.7  0.7  5.0  1.0  7466 3.05  48   6.7
63 16  2001 845  D   3  16.3 225.7  1.4  0.7  1.8 10787 2.60  48   3.9
64 16  2001 845  D   4  12.3 216.6  0.6  2.8  1.2 12580 2.83  58   4.6

Obs   BOR1    BOR2    BOR3    BOR      SW     FIB     TRS     TONS     LBS
1  0.79531 5.23906 4.19688 10.2313 2.51453 15.0906 205.709 53.2656 10929.28

The Mixed Procedure
                  Model Information
Data Set                     WORK.SUGAR
Dependent Variable           BOR1
Covariance Structure         Variance Components
Estimation Method            Type 3
Residual Variance Method     Factor
Fixed Effects SE Method      Model-Based
Degrees of Freedom Method    Satterthwaite

             Class Level Information
Class    Levels    Values
REP           4    1 2 3 4
VAR           4    321 384 555 845
TRT           4    A B C D

            Dimensions
Covariance Parameters            2
Columns in X                    25
Columns in Z                     4
Subjects                         1
Max Obs Per Subject             64
Observations Used               64
Observations Not Used            0
Total Observations              64

                         Type 3 Analysis of Variance
                        Sum of
Source        DF       Squares   Mean Square  Expected Mean Square
VAR            3      3.549219      1.183073  Var(Residual) + Q(VAR,VAR*TRT)

                        Type 3 Analysis of Variance
                                                  Error
Source    Error Term                                 DF    F Value    Pr > F
VAR       MS(Residual)                               45       1.87    0.1483

The Mixed Procedure
                         Type 3 Analysis of Variance
                        Sum of
Source        DF       Squares   Mean Square  Expected Mean Square
TRT            3     10.466719      3.488906  Var(Residual) + Q(TRT,VAR*TRT)
VAR*TRT        9      3.190156      0.354462  Var(Residual) + Q(VAR*TRT)
REP            3      1.149219      0.383073  Var(Residual) + 16 Var(REP)
Residual      45     28.473281      0.632740  Var(Residual)
```

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
TRT	MS(Residual)	45	5.51	0.0026
VAR*TRT	MS(Residual)	45	0.56	0.8219
REP	MS(Residual)	45	0.61	0.6149
Residual	.	.	.	.

Covariance Parameter Estimates

Cov Parm	Estimate
REP	-0.01560
Residual	0.6327

Fit Statistics

-2 Res Log Likelihood	134.9
AIC (smaller is better)	138.9
AICC (smaller is better)	139.2
BIC (smaller is better)	137.7

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
VAR	3	45	1.87	0.1483
TRT	3	45	5.51	0.0026
VAR*TRT	9	45	0.56	0.8219

Effect=TRT Method=Tukey-Kramer(P<0.05) Set=1

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
1		C	1.2250	0.1888	A
2		D	1.1500	0.1888	A
3		B	0.5375	0.1888	AB
4		A	0.2688	0.1888	B

Effect=VAR Method=Tukey-Kramer(P<0.05) Set=2

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
5	555		1.1125	0.1888	A
6	384		0.8375	0.1888	A
7	845		0.7813	0.1888	A
8	321		0.4500	0.1888	A

Effect=VAR*TRT Method=Tukey-Kramer(P<0.05) Set=3

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
9	555	C	1.8750	0.3928	A
10	555	D	1.7000	0.3928	A
11	384	D	1.2500	0.3928	A
12	845	D	1.1000	0.3928	A
13	845	C	1.0750	0.3928	A
14	321	C	0.9750	0.3928	A
15	384	C	0.9750	0.3928	A
16	845	B	0.9000	0.3928	A
17	384	B	0.6000	0.3928	A
18	321	D	0.5500	0.3928	A
19	384	A	0.5250	0.3928	A
20	555	A	0.4500	0.3928	A

21	555	B	0.4250	0.3928	A
22	321	B	0.2250	0.3928	A
23	321	A	0.05000	0.3928	A
24	845	A	0.05000	0.3928	A

The Mixed Procedure

Model Information

Data Set	WORK.SUGAR
Dependent Variable	BOR2
Covariance Structure	Variance Components
Estimation Method	Type 3
Residual Variance Method	Factor
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Satterthwaite

Class Level Information

Class	Levels	Values
REP	4	1 2 3 4
VAR	4	321 384 555 845
TRT	4	A B C D

Dimensions

Covariance Parameters	2
Columns in X	25
Columns in Z	4
Subjects	1
Max Obs Per Subject	64
Observations Used	64
Observations Not Used	0
Total Observations	64

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
VAR	3	197.674219	65.891406	Var(Residual) + Q(VAR,VAR*TRT)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
VAR	MS(Residual)	45	10.88	<.0001

The Mixed Procedure

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
TRT	3	523.046719	174.348906	Var(Residual) + Q(TRT,VAR*TRT)
VAR*TRT	9	249.613906	27.734878	Var(Residual) + Q(VAR*TRT)
REP	3	24.042969	8.014323	Var(Residual) + 16 Var(REP)
Residual	45	272.494531	6.055434	Var(Residual)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
TRT	MS(Residual)	45	28.79	<.0001
VAR*TRT	MS(Residual)	45	4.58	0.0003
REP	MS(Residual)	45	1.32	0.2785
Residual	.	.	.	.

Covariance Parameter

Estimates

Cov Parm	Estimate
REP	0.1224
Residual	6.0554

Fit Statistics

-2 Res Log Likelihood	245.7
AIC (smaller is better)	249.7
AICC (smaller is better)	250.0
BIC (smaller is better)	248.5

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
VAR	3	45	10.88	<.0001
TRT	3	45	28.79	<.0001
VAR*TRT	9	45	4.58	0.0003

Effect=TRT Method=Tukey-Kramer(P<0.05) Set=1

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
1		C	9.0937	0.6396	A
2		D	6.7125	0.6396	B
3		B	3.4312	0.6396	C
4		A	1.7187	0.6396	C

Effect=VAR Method=Tukey-Kramer(P<0.05) Set=2

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
5	555		7.7687	0.6396	A
6	384		5.9313	0.6396	AB
7	321		4.0062	0.6396	BC
8	845		3.2500	0.6396	C

Effect=VAR*TRT Method=Tukey-Kramer(P<0.05) Set=3

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
9	555	C	15.0750	1.2428	A
10	555	D	11.4250	1.2428	AB
11	384	C	9.0750	1.2428	ABC
12	384	D	8.9500	1.2428	ABC
13	321	C	7.6500	1.2428	BCD
14	845	C	4.5750	1.2428	CD
15	384	B	4.3250	1.2428	CD
16	321	D	3.5500	1.2428	CD
17	321	B	3.3750	1.2428	CD
18	555	B	3.0250	1.2428	CD
19	845	B	3.0000	1.2428	CD
20	845	D	2.9250	1.2428	CD
21	845	A	2.5000	1.2428	D
22	555	A	1.5500	1.2428	D
23	321	A	1.4500	1.2428	D
24	384	A	1.3750	1.2428	D

The Mixed Procedure

Model Information

Data Set	WORK.SUGAR
Dependent Variable	BOR3
Covariance Structure	Variance Components

Estimation Method	Type 3
Residual Variance Method	Factor
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Satterthwaite

Class Level Information

Class	Levels	Values
REP	4	1 2 3 4
VAR	4	321 384 555 845
TRT	4	A B C D

Dimensions

Covariance Parameters	2
Columns in X	25
Columns in Z	4
Subjects	1
Max Obs Per Subject	64
Observations Used	64
Observations Not Used	0
Total Observations	64

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
VAR	3	79.330625	26.443542	Var(Residual) + Q(VAR,VAR*TRT)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
VAR	MS(Residual)	45	8.03	0.0002

The Mixed Procedure

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
TRT	3	369.558125	123.186042	Var(Residual) + Q(TRT,VAR*TRT)
VAR*TRT	9	131.780625	14.642292	Var(Residual) + Q(VAR*TRT)
REP	3	20.208125	6.736042	Var(Residual) + 16 Var(REP)
Residual	45	148.241875	3.294264	Var(Residual)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
TRT	MS(Residual)	45	37.39	<.0001
VAR*TRT	MS(Residual)	45	4.44	0.0003
REP	MS(Residual)	45	2.04	0.1211
Residual	.	.	.	.

Covariance Parameter Estimates

Cov Parm	Estimate
REP	0.2151
Residual	3.2943

Fit Statistics

-2 Res Log Likelihood	217.8

AIC (smaller is better)	221.8
AICC (smaller is better)	222.0
BIC (smaller is better)	220.5

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
VAR	3	45	8.03	0.0002
TRT	3	45	37.39	<.0001
VAR*TRT	9	45	4.44	0.0003

Effect=TRT Method=Tukey-Kramer(P<0.05) Set=1

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
1		C	8.3563	0.5096	A
2		A	2.9500	0.5096	B
3		D	2.7625	0.5096	B
4		B	2.7188	0.5096	B

Effect=VAR Method=Tukey-Kramer(P<0.05) Set=2

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
5	555		5.3125	0.5096	A
6	384		4.7688	0.5096	A
7	321		4.3438	0.5096	A
8	845		2.3625	0.5096	B

Effect=VAR*TRT Method=Tukey-Kramer(P<0.05) Set=3

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
9	555	C	13.1250	0.9367	A
10	384	C	9.5000	0.9367	AB
11	321	C	6.0000	0.9367	BC
12	845	C	4.8000	0.9367	C
13	321	B	4.5250	0.9367	C
14	321	A	3.9000	0.9367	C
15	384	D	3.4250	0.9367	C
16	555	D	3.2500	0.9367	C
17	384	A	3.1750	0.9367	C
18	555	A	3.0250	0.9367	C
19	384	B	2.9750	0.9367	C
20	321	D	2.9500	0.9367	C
21	555	B	1.8500	0.9367	C
22	845	A	1.7000	0.9367	C
23	845	B	1.5250	0.9367	C
24	845	D	1.4250	0.9367	C

The Mixed Procedure

Model Information

Data Set	WORK.SUGAR
Dependent Variable	BOR
Covariance Structure	Variance Components
Estimation Method	Type 3
Residual Variance Method	Factor
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Satterthwaite

Class Level Information

Class	Levels	Values
REP	4	1 2 3 4
VAR	4	321 384 555 845
TRT	4	A B C D

Dimensions

Covariance Parameters	2
Columns in X	25
Columns in Z	4
Subjects	1
Max Obs Per Subject	64
Observations Used	64
Observations Not Used	0
Total Observations	64

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
VAR	3	546.921250	182.307083	Var(Residual) + Q(VAR,VAR*TRT)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
VAR	MS(Residual)	45	15.27	<.0001

The Mixed Procedure

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
TRT	3	1792.542500	597.514167	Var(Residual) + Q(TRT,VAR*TRT)
VAR*TRT	9	669.763750	74.418194	Var(Residual) + Q(VAR*TRT)
REP	3	89.846250	29.948750	Var(Residual) + 16 Var(REP)
Residual	45	537.423750	11.942750	Var(Residual)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
TRT	MS(Residual)	45	50.03	<.0001
VAR*TRT	MS(Residual)	45	6.23	<.0001
REP	MS(Residual)	45	2.51	0.0709
Residual	.	.	.	.

Covariance Parameter Estimates

Cov Parm	Estimate
REP	1.1254
Residual	11.9428

Fit Statistics

-2 Res Log Likelihood	280.2
AIC (smaller is better)	284.2
AICC (smaller is better)	284.5
BIC (smaller is better)	283.0

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F

VAR	3	45	15.27	<.0001
TRT	3	45	50.03	<.0001
VAR*TRT	9	45	6.23	<.0001

Effect=TRT   Method=Tukey-Kramer(P<0.05)   Set=1

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
1		C	18.6750	1.0138	A
2		D	10.6250	1.0138	B
3		B	6.6875	1.0138	C
4		A	4.9375	1.0138	C

Effect=VAR   Method=Tukey-Kramer(P<0.05)   Set=2

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
5	555		14.1938	1.0138	A
6	384		11.5375	1.0138	AB
7	321		8.8000	1.0138	BC
8	845		6.3937	1.0138	C

Effect=VAR*TRT   Method=Tukey-Kramer(P<0.05)   Set=3

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
9	555	C	30.0750	1.8075	A
10	384	C	19.5500	1.8075	B
11	555	D	16.3750	1.8075	BC
12	321	C	14.6250	1.8075	BCD
13	384	D	13.6250	1.8075	BCDE
14	845	C	10.4500	1.8075	CDEF
15	321	B	8.1250	1.8075	CDEF
16	384	B	7.9000	1.8075	CDEF
17	321	D	7.0500	1.8075	DEF
18	845	D	5.4500	1.8075	EF
19	845	B	5.4250	1.8075	EF
20	321	A	5.4000	1.8075	EF
21	555	B	5.3000	1.8075	EF
22	384	A	5.0750	1.8075	EF
23	555	A	5.0250	1.8075	EF
24	845	A	4.2500	1.8075	F

The Mixed Procedure

Model Information

Data Set	WORK.SUGAR
Dependent Variable	SW
Covariance Structure	Variance Components
Estimation Method	Type 3
Residual Variance Method	Factor
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Satterthwaite

Class Level Information

Class	Levels	Values
REP	4	1 2 3 4
VAR	4	321 384 555 845
TRT	4	A B C D

Dimensions

Covariance Parameters	2
Columns in X	25

Columns in Z	4
Subjects	1
Max Obs Per Subject	64
Observations Used	64
Observations Not Used	0
Total Observations	64

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
VAR	3	8.883592	2.961197	Var(Residual) + Q(VAR,VAR*TRT)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
VAR	MS(Residual)	45	71.10	<.0001

The Mixed Procedure

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
TRT	3	0.113355	0.037785	Var(Residual) + Q(TRT,VAR*TRT)
VAR*TRT	9	0.367814	0.040868	Var(Residual) + Q(VAR*TRT)
REP	3	0.199555	0.066518	Var(Residual) + 16 Var(REP)
Residual	45	1.874070	0.041646	Var(Residual)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
TRT	MS(Residual)	45	0.91	0.4451
VAR*TRT	MS(Residual)	45	0.98	0.4683
REP	MS(Residual)	45	1.60	0.2033
Residual	.	.	.	.

Covariance Parameter Estimates

Cov Parm	Estimate
REP	0.001555
Residual	0.04165

Fit Statistics

-2 Res Log Likelihood	7.2
AIC (smaller is better)	11.2
AICC (smaller is better)	11.5
BIC (smaller is better)	10.0

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
VAR	3	45	71.10	<.0001
TRT	3	45	0.91	0.4451
VAR*TRT	9	45	0.98	0.4683

Effect=TRT   Method=Tukey-Kramer(P<0.05)   Set=1

Obs	VAR	TRT	Estimate	Standard Error	Letter Group

1		D	2.5494	0.05469	A
2		A	2.5400	0.05469	A
3		C	2.5256	0.05469	A
4		B	2.4431	0.05469	A

Effect=VAR   Method=Tukey-Kramer(P<0.05)   Set=2

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
5	321		3.0431	0.05469	A
6	845		2.6713	0.05469	B
7	555		2.2625	0.05469	C
8	384		2.0813	0.05469	C

Effect=VAR*TRT   Method=Tukey-Kramer(P<0.05)   Set=3

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
9	321	A	3.1150	0.1039	A
10	321	D	3.0600	0.1039	A
11	321	C	3.0500	0.1039	A
12	321	B	2.9475	0.1039	A
13	845	C	2.7275	0.1039	AB
14	845	D	2.6825	0.1039	AB
15	845	B	2.6425	0.1039	ABC
16	845	A	2.6325	0.1039	ABCD
17	555	D	2.3525	0.1039	BCDE
18	555	B	2.3175	0.1039	BCDE
19	555	A	2.2625	0.1039	BCDE
20	384	C	2.2075	0.1039	BCDE
21	384	A	2.1500	0.1039	CDE
22	555	C	2.1175	0.1039	DE
23	384	D	2.1025	0.1039	E
24	384	B	1.8650	0.1039	E

The Mixed Procedure

Model Information

Data Set	WORK.SUGAR
Dependent Variable	FIB
Covariance Structure	Variance Components
Estimation Method	Type 3
Residual Variance Method	Factor
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Satterthwaite

Class Level Information

Class	Levels	Values
REP	4	1 2 3 4
VAR	4	321 384 555 845
TRT	4	A B C D

Dimensions

Covariance Parameters	2
Columns in X	25
Columns in Z	4
Subjects	1
Max Obs Per Subject	64
Observations Used	64
Observations Not Used	0

Total Observations 64

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
VAR	3	13.623125	4.541042	Var(Residual) + Q(VAR,VAR*TRT)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
VAR	MS(Residual)	45	0.39	0.7623

The Mixed Procedure

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
TRT	3	5.738125	1.912708	Var(Residual) + Q(TRT,VAR*TRT)
VAR*TRT	9	100.463125	11.162569	Var(Residual) + Q(VAR*TRT)
REP	3	35.688125	11.896042	Var(Residual) + 16 Var(REP)
Residual	45	526.821875	11.707153	Var(Residual)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
TRT	MS(Residual)	45	0.16	0.9205
VAR*TRT	MS(Residual)	45	0.95	0.4900
REP	MS(Residual)	45	1.02	0.3944
Residual	.	.	.	.

Covariance Parameter Estimates

Cov Parm	Estimate
REP	0.01181
Residual	11.7072

Fit Statistics

-2 Res Log Likelihood	276.5
AIC (smaller is better)	280.5
AICC (smaller is better)	280.8
BIC (smaller is better)	279.3

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
VAR	3	45	0.39	0.7623
TRT	3	45	0.16	0.9205
VAR*TRT	9	45	0.95	0.4900

Effect=TRT Method=Tukey-Kramer(P<0.05) Set=1

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
1		B	15.5813	0.8571	A
2		D	15.0125	0.8571	A
3		C	15.0000	0.8571	A
4		A	14.7688	0.8571	A

Effect=VAR Method=Tukey-Kramer(P<0.05) Set=2

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
5	321		15.7688	0.8571	A
6	555		15.2375	0.8571	A
7	845		14.8000	0.8571	A
8	384		14.5563	0.8571	A

Effect=VAR*TRT   Method=Tukey-Kramer(P<0.05)   Set=3

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
9	321	A	17.1500	1.7116	A
10	845	B	16.3000	1.7116	A
11	555	A	16.2250	1.7116	A
12	384	C	16.2000	1.7116	A
13	321	D	15.9750	1.7116	A
14	321	B	15.9250	1.7116	A
15	845	D	15.8500	1.7116	A
16	555	D	15.4750	1.7116	A
17	384	B	15.3500	1.7116	A
18	845	C	15.2750	1.7116	A
19	555	B	14.7500	1.7116	A
20	555	C	14.5000	1.7116	A
21	321	C	14.0250	1.7116	A
22	384	A	13.9250	1.7116	A
23	384	D	12.7500	1.7116	A
24	845	A	11.7750	1.7116	A

The Mixed Procedure

Model Information

Data Set	WORK.SUGAR
Dependent Variable	TRS
Covariance Structure	Variance Components
Estimation Method	Type 3
Residual Variance Method	Factor
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Satterthwaite

Class Level Information

Class	Levels	Values
REP	4	1 2 3 4
VAR	4	321 384 555 845
TRT	4	A B C D

Dimensions

Covariance Parameters	2
Columns in X	25
Columns in Z	4
Subjects	1
Max Obs Per Subject	64
Observations Used	64
Observations Not Used	0
Total Observations	64

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
VAR	3	3787.105625	1262.368542	Var(Residual) + Q(VAR,VAR*TRT)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
VAR	MS(Residual)	45	3.16	0.0335

The Mixed Procedure

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
TRT	3	861.531875	287.177292	Var(Residual) + Q(TRT,VAR*TRT)
VAR*TRT	9	4583.126875	509.236319	Var(Residual) + Q(VAR*TRT)
REP	3	1095.803125	365.267708	Var(Residual) + 16 Var(REP)
Residual	45	17962	399.151708	Var(Residual)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
TRT	MS(Residual)	45	0.72	0.5456
VAR*TRT	MS(Residual)	45	1.28	0.2762
REP	MS(Residual)	45	0.92	0.4412
Residual	.	.	.	.

Covariance Parameter Estimates

Cov Parm	Estimate
REP	-2.1177
Residual	399.15

Fit Statistics

-2 Res Log Likelihood	445.6
AIC (smaller is better)	449.6
AICC (smaller is better)	449.9
BIC (smaller is better)	448.4

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
VAR	3	45	3.16	0.0335
TRT	3	45	0.72	0.5456
VAR*TRT	9	45	1.28	0.2762

Effect=TRT Method=Tukey-Kramer(P<0.05) Set=1

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
1		A	210.96	4.9414	A
2		D	207.26	4.9414	A
3		C	202.89	4.9414	A
4		B	201.72	4.9414	A

Effect=VAR Method=Tukey-Kramer(P<0.05) Set=2

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
5	845		212.26	4.9414	A
6	384		209.64	4.9414	AB
7	321		208.33	4.9414	AB
8	555		192.61	4.9414	B

Effect=VAR*TRT Method=Tukey-Kramer(P<0.05) Set=3

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
9	845	A	232.15	9.9629	A
10	321	D	219.60	9.9629	A
11	384	A	216.82	9.9629	A
12	384	D	216.13	9.9629	A
13	321	C	215.58	9.9629	A
14	845	B	208.22	9.9629	A
15	384	B	208.05	9.9629	A
16	845	C	207.45	9.9629	A
17	321	A	207.23	9.9629	A
18	845	D	201.20	9.9629	A
19	555	B	199.70	9.9629	A
20	384	C	197.55	9.9629	A
21	555	D	192.13	9.9629	A
22	555	C	190.98	9.9629	A
23	321	B	190.93	9.9629	A
24	555	A	187.65	9.9629	A

The Mixed Procedure

Model Information

Data Set	WORK.SUGAR
Dependent Variable	TONS
Covariance Structure	Variance Components
Estimation Method	Type 3
Residual Variance Method	Factor
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Satterthwaite

Class Level Information

Class	Levels	Values
REP	4	1 2 3 4
VAR	4	321 384 555 845
TRT	4	A B C D

Dimensions

Covariance Parameters	2
Columns in X	25
Columns in Z	4
Subjects	1
Max Obs Per Subject	64
Observations Used	64
Observations Not Used	0
Total Observations	64

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
VAR	3	375.921875	125.307292	Var(Residual) + Q(VAR,VAR*TRT)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
VAR	MS(Residual)	45	3.28	0.0292

The Mixed Procedure

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
TRT	3	244.671875	81.557292	Var(Residual) + Q(TRT,VAR*TRT)

VAR*TRT	9	358.140625	39.793403	Var(Residual) + Q(VAR*TRT)
REP	3	1440.296875	480.098958	Var(Residual) + 16 Var(REP)
Residual	45	1717.453125	38.165625	Var(Residual)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
TRT	MS(Residual)	45	2.14	0.1088
VAR*TRT	MS(Residual)	45	1.04	0.4224
REP	MS(Residual)	45	12.58	<.0001
Residual	.	.	.	.

Covariance Parameter Estimates

Cov Parm	Estimate
REP	27.6208
Residual	38.1656

Fit Statistics

-2 Res Log Likelihood	340.8
AIC (smaller is better)	344.8
AICC (smaller is better)	345.1
BIC (smaller is better)	343.6

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
VAR	3	45	3.28	0.0292
TRT	3	45	2.14	0.1088
VAR*TRT	9	45	1.04	0.4224

Effect=TRT Method=Tukey-Kramer(P<0.05) Set=1

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
1		B	56.5000	3.0480	A
2		D	53.0625	3.0480	A
3		C	52.0625	3.0480	A
4		A	51.4375	3.0480	A

Effect=VAR Method=Tukey-Kramer(P<0.05) Set=2

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
5	321		55.6875	3.0480	A
6	555		55.6250	3.0480	A
7	845		51.4375	3.0480	A
8	384		50.3125	3.0480	A

Effect=VAR*TRT Method=Tukey-Kramer(P<0.05) Set=3

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
9	555	B	62.2500	4.0554	A
10	321	B	60.5000	4.0554	A
11	321	C	57.2500	4.0554	A
12	555	D	55.7500	4.0554	A
13	845	B	54.0000	4.0554	A
14	384	D	53.7500	4.0554	A
15	321	D	53.2500	4.0554	A
16	845	A	53.0000	4.0554	A

17	555	A	53.0000	4.0554	A
18	321	A	51.7500	4.0554	A
19	555	C	51.5000	4.0554	A
20	384	C	50.2500	4.0554	A
21	845	D	49.5000	4.0554	A
22	384	B	49.2500	4.0554	A
23	845	C	49.2500	4.0554	A
24	384	A	48.0000	4.0554	A

The Mixed Procedure

Model Information

Data Set	WORK.SUGAR
Dependent Variable	LBS
Covariance Structure	Variance Components
Estimation Method	Type 3
Residual Variance Method	Factor
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Satterthwaite

Class Level Information

Class	Levels	Values
REP	4	1 2 3 4
VAR	4	321 384 555 845
TRT	4	A B C D

Dimensions

Covariance Parameters	2
Columns in X	25
Columns in Z	4
Subjects	1
Max Obs Per Subject	64
Observations Used	64
Observations Not Used	0
Total Observations	64

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
VAR	3	9003690	3001230	Var(Residual) + Q(VAR,VAR*TRT)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
VAR	MS(Residual)	45	1.18	0.3279

The Mixed Procedure

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
TRT	3	4439372	1479791	Var(Residual) + Q(TRT,VAR*TRT)
VAR*TRT	9	37284259	4142695	Var(Residual) + Q(VAR*TRT)
REP	3	33736408	11245469	Var(Residual) + 16 Var(REP)
Residual	45	114435757	2543017	Var(Residual)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
TRT	MS(Residual)	45	0.58	0.6300

VAR*TRT	MS(Residual)	45	1.63	0.1359
REP	MS(Residual)	45	4.42	0.0083
Residual	.	.	.	.

Covariance Parameter Estimates

Cov Parm	Estimate
REP	543903
Residual	2543017

Fit Statistics

-2 Res Log Likelihood	870.8
AIC (smaller is better)	874.8
AICC (smaller is better)	875.1
BIC (smaller is better)	873.6

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
VAR	3	45	1.18	0.3279
TRT	3	45	0.58	0.6300
VAR*TRT	9	45	1.63	0.1359

Effect=TRT Method=Tukey-Kramer(P<0.05) Set=1

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
1		B	11309	543.06	A
2		D	10983	543.06	A
3		A	10847	543.06	A
4		C	10578	543.06	A

Effect=VAR Method=Tukey-Kramer(P<0.05) Set=2

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
5	321		11538	543.06	A
6	845		10925	543.06	A
7	555		10695	543.06	A
8	384		10559	543.06	A

Effect=VAR*TRT Method=Tukey-Kramer(P<0.05) Set=3

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
9	555	B	12392	878.48	A
10	845	A	12323	878.48	A
11	321	C	12285	878.48	A
12	321	D	11674	878.48	A
13	384	D	11602	878.48	A
14	321	B	11420	878.48	A
15	845	B	11196	878.48	A
16	321	A	10774	878.48	A
17	555	D	10660	878.48	A
18	384	A	10435	878.48	A
19	384	B	10229	878.48	A
20	845	C	10186	878.48	A
21	845	D	9996.00	878.48	A
22	384	C	9968.25	878.48	A
23	555	C	9873.25	878.48	A
24	555	A	9856.25	878.48	A

APPENDIX E: 2002 SUGARCANE ECONOMIC THRESHOLD SAS OUTPUT

Obs	NUM	VAR	YEAR	TRT	REP	FIB1	FIB2	FIB3	TRS1	TRS2	TRS3
1	1	321	2002	A	1	14.4	11.6	10.7	264.7	284.1	249.8
2	1	321	2002	A	2	12.5	11.3	10.9	242.5	260.1	204.6
3	1	321	2002	A	3	14.9	12.6	12.3	239.7	251.3	198.7
4	1	321	2002	A	4	12.9	10.4	10.4	247.2	249.7	199.8
5	2	321	2002	B	1	13.3	11.7	11.3	258.9	264.9	221.9
6	2	321	2002	B	2	13.0	11.7	11.0	254.8	268.3	236.2
7	2	321	2002	B	3	14.4	11.5	12.5	244.7	254.2	244.9
8	2	321	2002	B	4	13.8	12.0	11.2	251.2	265.1	238.2
9	3	321	2002	C	1	14.2	11.4	11.8	243.6	252.9	203.5
10	3	321	2002	C	2	13.2	13.0	11.6	256.8	252.9	217.7
11	3	321	2002	C	3	13.6	12.3	12.0	230.5	238.1	199.2
12	3	321	2002	C	4	14.4	12.9	12.7	251.5	264.5	226.7
13	4	321	2002	D	1	12.7	11.5	10.7	246.8	258.2	207.1
14	4	321	2002	D	2	13.5	12.1	11.2	257.8	265.6	232.6
15	4	321	2002	D	3	13.1	11.6	11.2	255.8	259.8	229.3
16	4	321	2002	D	4	14.8	13.3	14.0	257.1	262.8	243.8
17	5	384	2002	A	1	11.9	11.8	11.4	268.4	281.0	262.1
18	5	384	2002	A	2	13.0	11.9	13.4	271.6	263.4	278.3
19	5	384	2002	A	3	14.0	12.1	11.6	278.7	286.7	239.1
20	5	384	2002	A	4	13.6	12.8	12.3	267.1	251.2	238.3
21	6	384	2002	B	1	13.8	12.0	11.2	276.2	282.6	244.4

Obs	BOR1	BOR2	BOR3	LBS	SW	TONS	BOR	FIB	TRS
1	0.4	3.7	3.7	8214	2.3	31	7.8	12.2333	266.200
2	0.8	3.9	2.6	7486	2.4	32	7.3	11.5667	235.733
3	0.0	1.0	2.1	7094	2.2	31	3.1	13.2667	229.900
4	1.0	3.5	2.0	5198	2.0	22	6.5	11.2333	232.233
5	0.4	3.9	2.1	7896	2.4	32	6.4	12.1000	248.567
6	0.4	3.9	2.3	7924	2.6	31	6.6	11.9000	253.100
7	1.1	3.8	2.5	10799	2.0	44	7.4	12.8000	247.933
8	0.5	4.5	2.0	7912	2.3	31	7.0	12.3333	251.500
9	1.1	11.7	6.4	6034	1.9	26	19.2	12.4667	233.333
10	3.0	19.4	3.0	6492	2.2	27	25.4	12.6000	242.467
11	5.4	31.2	4.3	10639	1.8	48	40.9	12.6333	222.600
12	4.1	17.5	2.4	7340	2.7	30	24.0	13.3333	247.567
13	0.0	5.1	4.7	6894	2.1	29	9.8	11.6333	237.367
14	4.1	5.3	3.3	8462	2.3	34	12.7	12.2667	252.000
15	3.8	7.5	2.7	5859	2.0	24	14.0	11.9667	248.300
16	3.5	6.5	4.5	9238	2.3	36	14.5	14.0333	254.567
17	0.0	1.9	2.4	8101	1.7	30	4.3	11.7000	270.500
18	0.0	4.6	0.6	9472	1.3	35	5.2	12.7667	271.100
19	0.0	0.0	0.9	7461	1.7	28	0.9	12.5667	268.167
20	0.5	6.4	4.4	9155	1.7	36	11.3	12.9000	252.200
21	0.4	2.2	6.7	8138	1.6	30	9.3	12.3333	267.733

Obs	NUM	VAR	YEAR	TRT	REP	FIB1	FIB2	FIB3	TRS1	TRS2	TRS3
22	6	384	2002	B	2	14.3	12.4	13.0	256.7	257.3	219.3
23	6	384	2002	B	3	12.6	10.4	11.4	274.5	276.2	223.4
24	6	384	2002	B	4	12.5	11.0	11.4	277.9	285.5	261.0
25	7	384	2002	C	1	12.8	11.2	10.9	267.8	272.7	240.3
26	7	384	2002	C	2	12.8	13.4	14.4	251.4	230.9	167.1
27	7	384	2002	C	3	14.2	13.0	13.3	271.4	260.2	210.3
28	7	384	2002	C	4	13.3	11.7	12.0	265.0	265.4	215.8
29	8	384	2002	D	1	13.7	12.9	13.8	270.3	246.6	208.5
30	8	384	2002	D	2	13.3	12.4	13.2	268.9	257.6	213.0

31	8	384	2002	D	3	13.0	12.1	11.0	292.0	296.5	262.7
32	8	384	2002	D	4	12.9	11.6	11.7	265.7	260.0	247.8
33	13	555	2002	A	1	14.7	13.2	11.6	281.8	292.7	267.1
34	13	555	2002	A	2	13.9	12.6	10.5	282.2	283.6	248.9
35	13	555	2002	A	3	14.9	12.5	11.5	229.3	264.3	209.9
36	13	555	2002	A	4	14.3	13.0	11.6	282.2	297.8	275.8
37	14	555	2002	B	1	14.5	13.8	12.1	288.3	289.9	256.9
38	14	555	2002	B	2	13.2	12.3	10.4	268.6	260.9	237.0
39	14	555	2002	B	3	13.3	11.9	10.5	255.2	261.5	215.7
40	14	555	2002	B	4	14.8	13.2	12.7	278.5	286.4	251.3
41	15	555	2002	C	1	13.3	13.1	11.9	251.1	233.6	204.3
42	15	555	2002	C	2	13.0	11.9	11.8	245.6	238.2	192.6

Obs	BOR1	BOR2	BOR3	LBS	SW	TONS	BOR	FIB	TRS
22	1.0	1.9	1.0	8761	1.4	36	3.9	13.2333	244.433
23	0.5	1.5	3.0	9209	1.4	36	5.0	11.4667	258.033
24	0.5	3.1	2.6	6816	1.6	25	6.2	11.6333	274.800
25	0.5	26.0	7.5	9331	1.4	36	34.0	11.6333	260.267
26	15.2	29.0	11.3	6189	1.4	29	55.5	13.5333	216.467
27	9.6	22.6	11.1	7780	1.3	31	43.3	13.5000	247.300
28	1.0	23.5	7.8	6620	1.5	27	32.3	12.3333	248.733
29	0.5	2.3	4.1	6802	1.4	28	6.9	13.4667	241.800
30	1.5	1.8	9.3	10402	1.6	42	12.6	12.9667	246.500
31	0.0	2.8	2.9	11500	1.9	41	5.7	12.0333	283.733
32	1.1	2.6	0.0	6863	1.5	27	3.7	12.0667	257.833
33	0.0	2.4	1.4	6873	1.5	26	3.8	13.1667	280.533
34	1.0	1.9	2.9	5546	1.6	29	5.8	12.3333	271.567
35	0.9	7.8	4.6	10607	1.7	42	13.3	12.9667	234.500
36	0.5	1.5	0.0	7077	1.6	34	2.0	12.9667	285.267
37	0.0	6.3	2.1	7200	1.5	30	8.4	13.4667	278.367
38	0.0	0.9	5.3	7768	1.6	29	6.2	11.9667	255.500
39	1.0	8.9	4.4	10633	1.4	29	14.3	11.9000	244.133
40	1.0	3.1	2.6	7408	1.3	30	6.7	13.5667	272.067
41	3.9	29.5	11.1	7296	1.4	28	44.5	12.7667	229.667
42	7.3	29.9	7.3	7060	1.4	24	44.5	12.2333	225.467

Obs	NUM	VAR	YEAR	TRT	REP	FIB1	FIB2	FIB3	TRS1	TRS2	TRS3
43	15	555	2002	C	3	14.5	13.0	13.5	261.6	271.1	223.3
44	15	555	2002	C	4	14.9	14.4	13.2	261.5	261.0	234.7
45	16	555	2002	D	1	15.0	14.1	12.1	257.1	266.5	261.5
46	16	555	2002	D	2	14.5	13.8	8.1	271.9	279.1	288.8
47	16	555	2002	D	3	13.3	11.9	10.5	264.6	268.9	230.9
48	16	555	2002	D	4	14.8	14.0	11.9	285.1	297.9	283.2
49	9	845	2002	A	1	18.2	16.5	14.2	255.1	262.0	229.3
50	9	845	2002	A	2	17.3	17.2	14.7	252.1	252.3	236.1
51	9	845	2002	A	3	15.1	15.0	13.1	246.2	244.0	190.4
52	9	845	2002	A	4	17.2	15.0	14.3	244.7	255.6	235.9
53	10	845	2002	B	1	17.9	16.7	14.1	249.0	250.9	223.9
54	10	845	2002	B	2	16.2	14.4	14.0	251.9	265.7	229.7
55	10	845	2002	B	3	14.9	13.8	12.8	251.0	244.6	184.0
56	10	845	2002	B	4	15.8	15.0	12.4	237.2	234.9	206.6
57	11	845	2002	C	1	18.2	15.5	14.7	245.8	259.1	244.5
58	11	845	2002	C	2	15.8	14.8	13.8	237.9	216.8	151.3
59	11	845	2002	C	3	16.8	16.1	14.5	237.1	238.8	214.2
60	11	845	2002	C	4	17.6	17.2	15.0	226.5	226.3	193.9
61	12	845	2002	D	1	18.4	17.6	15.6	251.8	256.1	252.6
62	12	845	2002	D	2	16.1	14.2	12.6	231.5	234.3	187.2
63	12	845	2002	D	3	18.1	17.8	15.1	239.3	249.7	250.1

Obs	BOR1	BOR2	BOR3	LBS	SW	TONS	BOR	FIB	TRS
43	2.5	23.5	10.3	8995	1.5	32	36.3	13.6667	252.000
44	5.3	23.7	10.6	4123	1.5	22	39.6	14.1667	252.400
45	0.0	0.9	0.5	8312	1.7	30	1.4	13.7333	261.700
46	1.5	3.9	6.4	7112	1.8	31	11.8	12.1333	279.933
47	2.0	9.0	7.0	9866	1.5	24	18.0	11.9000	254.800
48	0.0	4.5	3.0	6989	1.6	29	7.5	13.5667	288.733
49	0.4	4.4	1.9	6548	2.0	25	6.7	16.3000	248.800
50	0.9	4.1	1.6	7279	1.9	20	6.6	16.4000	246.833
51	1.3	4.2	1.4	9609	1.7	44	6.9	14.4000	226.867
52	1.0	4.8	1.9	8463	2.0	25	7.7	15.5000	245.400
53	0.0	5.7	4.1	7336	1.8	26	9.8	16.2333	241.267
54	0.9	4.2	5.1	7234	2.2	30	10.2	14.8667	249.100
55	0.0	5.1	5.8	6580	1.7	44	10.9	13.8333	226.533
56	0.4	5.6	5.3	6706	2.0	27	11.3	14.4000	226.233
57	1.5	14.0	3.0	7027	2.0	32	18.5	16.1333	249.800
58	0.8	10.7	2.3	4766	1.9	31	13.8	14.8000	202.000
59	2.7	10.7	9.5	7375	2.3	36	22.9	15.8000	230.033
60	3.0	10.0	6.1	4826	2.0	16	19.1	16.6000	215.567
61	0.4	5.9	1.0	7592	1.8	32	7.3	17.2000	253.500
62	0.4	5.9	1.7	6717	2.2	25	8.0	14.3000	217.667
63	2.2	5.8	0.0	5814	2.0	39	8.0	17.0000	246.367

Obs	NUM	VAR	YEAR	TRT	REP	FIB1	FIB2	FIB3	TRS1	TRS2	TRS3
64	12	845	2002	D	4	17.0	15.2	14.3	247.1	264.8	253.4

Obs	BOR1	BOR2	BOR3	LBS	SW	TONS	BOR	FIB	TRS
64	1.3	5.9	0.9	7408	2.0	24	8.1	15.5000	255.100

Obs	BOR1	BOR2	BOR3	BOR	SW	FIB1	FIB2	FIB3
1	1.65625	8.27031	4.02031	13.9469	1.8125	14.4984	13.1922	12.3531

Obs	FIB	TRS1	TRS2	TRS3	TRS	TONS	LBS
1	13.3479	257.75	261.494	228.913	249.385	30.7813	7659.78

The Mixed Procedure

Model Information

Data Set	WORK.SUGAR
Dependent Variable	BOR1
Covariance Structure	Variance Components
Estimation Method	Type 3
Residual Variance Method	Factor
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Satterthwaite

Class Level Information

Class	Levels	Values
REP	4	1 2 3 4
VAR	4	321 384 555 845
TRT	4	A B C D

Dimensions

Covariance Parameters	2
Columns in X	25
Columns in Z	4
Subjects	1
Max Obs Per Subject	64
Observations Used	64

Observations Not Used	0
Total Observations	64

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
VAR	3	8.118750	2.706250	Var(Residual) + Q(VAR,VAR*TRT)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
VAR	MS(Residual)	45	0.72	0.5438

The Mixed Procedure

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
TRT	3	144.075000	48.025000	Var(Residual) + Q(TRT,VAR*TRT)
VAR*TRT	9	50.488750	5.609861	Var(Residual) + Q(VAR*TRT)
REP	3	30.361250	10.120417	Var(Residual) + 16 Var(REP)
Residual	45	168.533750	3.745194	Var(Residual)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
TRT	MS(Residual)	45	12.82	<.0001
VAR*TRT	MS(Residual)	45	1.50	0.1780
REP	MS(Residual)	45	2.70	0.0567
Residual	.	.	.	.

Covariance Parameter Estimates

Cov Parm	Estimate
REP	0.3985
Residual	3.7452

Fit Statistics

-2 Res Log Likelihood	224.8
AIC (smaller is better)	228.8
AICC (smaller is better)	229.0
BIC (smaller is better)	227.5

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
VAR	3	45	0.72	0.5438
TRT	3	45	12.82	<.0001
VAR*TRT	9	45	1.50	0.1780

Effect=TRT   Method=Tukey-Kramer(P<0.05)   Set=1

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
1		C	4.1813	0.5777	A
2		D	1.3938	0.5777	B
3		A	0.5438	0.5777	B
4		B	0.5063	0.5777	B

Effect=VAR   Method=Tukey-Kramer(P<0.05)   Set=2

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
5	384		2.0188	0.5777	A
6	321		1.8500	0.5777	A
7	555		1.6813	0.5777	A
8	845		1.0750	0.5777	A

Effect=VAR*TRT   Method=Tukey-Kramer(P<0.05)   Set=3

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
9	384	C	6.5750	1.0178	A
10	555	C	4.7500	1.0178	AB
11	321	C	3.4000	1.0178	AB
12	321	D	2.8500	1.0178	AB
13	845	C	2.0000	1.0178	AB
14	845	D	1.0750	1.0178	B
15	845	A	0.9000	1.0178	B
16	555	D	0.8750	1.0178	B
17	384	D	0.7750	1.0178	B
18	321	B	0.6000	1.0178	B
19	384	B	0.6000	1.0178	B
20	555	A	0.6000	1.0178	B
21	321	A	0.5500	1.0178	B
22	555	B	0.5000	1.0178	B
23	845	B	0.3250	1.0178	B
24	384	A	0.1250	1.0178	B

The Mixed Procedure

Model Information

Data Set	WORK.SUGAR
Dependent Variable	BOR2
Covariance Structure	Variance Components
Estimation Method	Type 3
Residual Variance Method	Factor
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Satterthwaite

Class Level Information

Class	Levels	Values
REP	4	1 2 3 4
VAR	4	321 384 555 845
TRT	4	A B C D

Dimensions

Covariance Parameters	2
Columns in X	25
Columns in Z	4
Subjects	1
Max Obs Per Subject	64
Observations Used	64
Observations Not Used	0
Total Observations	64

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
VAR	3	80.329219	26.776406	Var(Residual) + Q(VAR,VAR*TRT)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
VAR	MS(Residual)	45	3.08	0.0370

The Mixed Procedure

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
TRT	3	3364.602969	1121.534323	Var(Residual) + Q(TRT,VAR*TRT)
VAR*TRT	9	557.253906	61.917101	Var(Residual) + Q(VAR*TRT)
REP	3	15.307969	5.102656	Var(Residual) + 16 Var(REP)
Residual	45	391.659531	8.703545	Var(Residual)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
TRT	MS(Residual)	45	128.86	<.0001
VAR*TRT	MS(Residual)	45	7.11	<.0001
REP	MS(Residual)	45	0.59	0.6271
Residual	.	.	.	.

Covariance Parameter Estimates

Cov Parm	Estimate
REP	-0.2251
Residual	8.7035

Fit Statistics

-2 Res Log Likelihood	260.7
AIC (smaller is better)	264.7
AICC (smaller is better)	264.9
BIC (smaller is better)	263.4

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
VAR	3	45	3.08	0.0370
TRT	3	45	128.86	<.0001
VAR*TRT	9	45	7.11	<.0001

Effect=TRT Method=Tukey-Kramer(P<0.05) Set=1

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
1		C	20.8063	0.6984	A
2		D	4.7312	0.6984	B
3		B	4.0375	0.6984	B
4		A	3.5063	0.6984	B

Effect=VAR Method=Tukey-Kramer(P<0.05) Set=2

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
5	555		9.8563	0.6984	A
6	321		8.2750	0.6984	AB
7	384		8.2625	0.6984	AB
8	845		6.6875	0.6984	B

Effect=VAR*TRT Method=Tukey-Kramer(P<0.05) Set=3

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
9	555	C	26.6500	1.4559	A
10	384	C	25.2750	1.4559	A
11	321	C	19.9500	1.4559	A
12	845	C	11.3500	1.4559	B
13	321	D	6.1000	1.4559	BC
14	845	D	5.8750	1.4559	BC
15	845	B	5.1500	1.4559	BC
16	555	B	4.8000	1.4559	BC
17	555	D	4.5750	1.4559	BC
18	845	A	4.3750	1.4559	BC
19	321	B	4.0250	1.4559	BC
20	555	A	3.4000	1.4559	C
21	384	A	3.2250	1.4559	C
22	321	A	3.0250	1.4559	C
23	384	D	2.3750	1.4559	C
24	384	B	2.1750	1.4559	C

The Mixed Procedure

Model Information

Data Set	WORK.SUGAR
Dependent Variable	BOR3
Covariance Structure	Variance Components
Estimation Method	Type 3
Residual Variance Method	Factor
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Satterthwaite

Class Level Information

Class	Levels	Values
REP	4	1 2 3 4
VAR	4	321 384 555 845
TRT	4	A B C D

Dimensions

Covariance Parameters	2
Columns in X	25
Columns in Z	4
Subjects	1
Max Obs Per Subject	64
Observations Used	64
Observations Not Used	0
Total Observations	64

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
VAR	3	44.231719	14.743906	Var(Residual) + Q(VAR,VAR*TRT)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
VAR	MS(Residual)	45	3.67	0.0189

The Mixed Procedure

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
TRT	3	223.134219	74.378073	Var(Residual) + Q(TRT,VAR*TRT)
VAR*TRT	9	106.995156	11.888351	Var(Residual) + Q(VAR*TRT)
REP	3	8.745469	2.915156	Var(Residual) + 16 Var(REP)
Residual	45	180.697031	4.015490	Var(Residual)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
TRT	MS(Residual)	45	18.52	<.0001
VAR*TRT	MS(Residual)	45	2.96	0.0075
REP	MS(Residual)	45	0.73	0.5418
Residual	.	.	.	.

Covariance Parameter Estimates

Cov Parm	Estimate
REP	-0.06877
Residual	4.0155

Fit Statistics

-2 Res Log Likelihood	224.2
AIC (smaller is better)	228.2
AICC (smaller is better)	228.4
BIC (smaller is better)	226.9

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
VAR	3	45	3.67	0.0189
TRT	3	45	18.52	<.0001
VAR*TRT	9	45	2.96	0.0075

Effect=TRT Method=Tukey-Kramer(P<0.05) Set=1

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
1		C	7.1250	0.4835	A
2		B	3.5563	0.4835	B
3		D	3.2500	0.4835	B
4		A	2.1500	0.4835	B

Effect=VAR Method=Tukey-Kramer(P<0.05) Set=2

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
5	555		4.9688	0.4835	A
6	384		4.7250	0.4835	A
7	845		3.2250	0.4835	A
8	321		3.1625	0.4835	A

Effect=VAR*TRT Method=Tukey-Kramer(P<0.05) Set=3

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
9	555	C	9.8250	0.9933	A
10	384	C	9.4250	0.9933	A
11	845	C	5.2250	0.9933	AB
12	845	B	5.0750	0.9933	AB

13	555	D	4.2250	0.9933	B
14	384	D	4.0750	0.9933	B
15	321	C	4.0250	0.9933	B
16	321	D	3.8000	0.9933	B
17	555	B	3.6000	0.9933	B
18	384	B	3.3250	0.9933	B
19	321	A	2.6000	0.9933	B
20	555	A	2.2250	0.9933	B
21	321	B	2.2250	0.9933	B
22	384	A	2.0750	0.9933	B
23	845	A	1.7000	0.9933	B
24	845	D	0.9000	0.9933	B

The Mixed Procedure

Model Information

Data Set	WORK.SUGAR
Dependent Variable	BOR
Covariance Structure	Variance Components
Estimation Method	Type 3
Residual Variance Method	Factor
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Satterthwaite

Class Level Information

Class	Levels	Values
REP	4	1 2 3 4
VAR	4	321 384 555 845
TRT	4	A B C D

Dimensions

Covariance Parameters	2
Columns in X	25
Columns in Z	4
Subjects	1
Max Obs Per Subject	64
Observations Used	64
Observations Not Used	0
Total Observations	64

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
VAR	3	269.845625	89.948542	Var(Residual) + Q(VAR,VAR*TRT)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
VAR	MS(Residual)	45	4.09	0.0120

The Mixed Procedure

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
TRT	3	7121.471875	2373.823958	Var(Residual) + Q(TRT,VAR*TRT)
VAR*TRT	9	1348.286875	149.809653	Var(Residual) + Q(VAR*TRT)
REP	3	113.136875	37.712292	Var(Residual) + 16 Var(REP)
Residual	45	990.778125	22.017292	Var(Residual)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
TRT	MS(Residual)	45	107.82	<.0001
VAR*TRT	MS(Residual)	45	6.80	<.0001
REP	MS(Residual)	45	1.71	0.1778
Residual	.	.	.	.

Covariance Parameter Estimates

Cov Parm	Estimate
REP	0.9809
Residual	22.0173

Fit Statistics

-2 Res Log Likelihood	308.4
AIC (smaller is better)	312.4
AICC (smaller is better)	312.7
BIC (smaller is better)	311.2

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
VAR	3	45	4.09	0.0120
TRT	3	45	107.82	<.0001
VAR*TRT	9	45	6.80	<.0001

Effect=TRT Method=Tukey-Kramer(P<0.05) Set=1

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
1		C	32.1125	1.2733	A
2		D	9.3750	1.2733	B
3		B	8.1000	1.2733	B
4		A	6.2000	1.2733	B

Effect=VAR Method=Tukey-Kramer(P<0.05) Set=2

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
5	555		16.5063	1.2733	A
6	384		15.0063	1.2733	AB
7	321		13.2875	1.2733	AB
8	845		10.9875	1.2733	B

Effect=VAR*TRT Method=Tukey-Kramer(P<0.05) Set=3

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
9	384	C	41.2750	2.3978	A
10	555	C	41.2250	2.3978	A
11	321	C	27.3750	2.3978	B
12	845	C	18.5750	2.3978	BC
13	321	D	12.7500	2.3978	CD
14	845	B	10.5500	2.3978	CD
15	555	D	9.6750	2.3978	CD
16	555	B	8.9000	2.3978	CD
17	845	D	7.8500	2.3978	CD
18	384	D	7.2250	2.3978	CD
19	845	A	6.9750	2.3978	CD
20	321	B	6.8500	2.3978	CD

21	555	A	6.2250	2.3978	D
22	321	A	6.1750	2.3978	D
23	384	B	6.1000	2.3978	D
24	384	A	5.4250	2.3978	D

The Mixed Procedure

Model Information

Data Set	WORK.SUGAR
Dependent Variable	SW
Covariance Structure	Variance Components
Estimation Method	Type 3
Residual Variance Method	Factor
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Satterthwaite

Class Level Information

Class	Levels	Values
REP	4	1 2 3 4
VAR	4	321 384 555 845
TRT	4	A B C D

Dimensions

Covariance Parameters	2
Columns in X	25
Columns in Z	4
Subjects	1
Max Obs Per Subject	64
Observations Used	64
Observations Not Used	0
Total Observations	64

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
VAR	3	5.563750	1.854583	Var(Residual) + Q(VAR,VAR*TRT)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
VAR	MS(Residual)	45	54.50	<.0001

The Mixed Procedure

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
TRT	3	0.078750	0.026250	Var(Residual) + Q(TRT,VAR*TRT)
VAR*TRT	9	0.287500	0.031944	Var(Residual) + Q(VAR*TRT)
REP	3	0.128750	0.042917	Var(Residual) + 16 Var(REP)
Residual	45	1.531250	0.034028	Var(Residual)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
TRT	MS(Residual)	45	0.77	0.5161
VAR*TRT	MS(Residual)	45	0.94	0.5017
REP	MS(Residual)	45	1.26	0.2990
Residual	.	.	.	.

Covariance Parameter
Estimates

Cov Parm	Estimate
REP	0.000556
Residual	0.03403

Fit Statistics

-2 Res Log Likelihood	-3.2
AIC (smaller is better)	0.8
AICC (smaller is better)	1.1
BIC (smaller is better)	-0.4

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
VAR	3	45	54.50	<.0001
TRT	3	45	0.77	0.5161
VAR*TRT	9	45	0.94	0.5017

Effect=TRT Method=Tukey-Kramer(P<0.05) Set=1

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
1		D	1.8563	0.04760	A
2		A	1.8313	0.04760	A
3		B	1.8000	0.04760	A
4		C	1.7625	0.04760	A

Effect=VAR Method=Tukey-Kramer(P<0.05) Set=2

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
5	321		2.2188	0.04760	A
6	845		1.9688	0.04760	B
7	555		1.5375	0.04760	C
8	384		1.5250	0.04760	C

Effect=VAR*TRT Method=Tukey-Kramer(P<0.05) Set=3

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
9	321	B	2.3250	0.09298	A
10	321	A	2.2250	0.09298	A
11	321	D	2.1750	0.09298	A
12	321	C	2.1500	0.09298	A
13	845	C	2.0500	0.09298	AB
14	845	D	2.0000	0.09298	AB
15	845	B	1.9250	0.09298	ABC
16	845	A	1.9000	0.09298	ABCD
17	555	D	1.6500	0.09298	BCDE
18	384	D	1.6000	0.09298	BCDE
19	384	A	1.6000	0.09298	BCDE
20	555	A	1.6000	0.09298	BCDE
21	384	B	1.5000	0.09298	CDE
22	555	B	1.4500	0.09298	DE
23	555	C	1.4500	0.09298	DE
24	384	C	1.4000	0.09298	E

The Mixed Procedure

Model Information

Data Set	WORK.SUGAR
Dependent Variable	FIB1
Covariance Structure	Variance Components
Estimation Method	Type 3
Residual Variance Method	Factor
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Satterthwaite

Class Level Information

Class	Levels	Values
REP	4	1 2 3 4
VAR	4	321 384 555 845
TRT	4	A B C D

Dimensions

Covariance Parameters	2
Columns in X	25
Columns in Z	4
Subjects	1
Max Obs Per Subject	64
Observations Used	64
Observations Not Used	0
Total Observations	64

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
VAR	3	131.559219	43.853073	Var(Residual) + Q(VAR,VAR*TRT)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
VAR	MS(Residual)	45	58.35	<.0001

The Mixed Procedure

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
TRT	3	1.220469	0.406823	Var(Residual) + Q(TRT,VAR*TRT)
VAR*TRT	9	3.157656	0.350851	Var(Residual) + Q(VAR*TRT)
REP	3	4.650469	1.550156	Var(Residual) + 16 Var(REP)
Residual	45	33.822031	0.751601	Var(Residual)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
TRT	MS(Residual)	45	0.54	0.6565
VAR*TRT	MS(Residual)	45	0.47	0.8891
REP	MS(Residual)	45	2.06	0.1186
Residual	.	.	.	.

Covariance Parameter Estimates

Cov Parm	Estimate
REP	0.04991
Residual	0.7516

Fit Statistics

-2 Res Log Likelihood	146.9
AIC (smaller is better)	150.9
AICC (smaller is better)	151.1
BIC (smaller is better)	149.6

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
VAR	3	45	58.35	<.0001
TRT	3	45	0.54	0.6565
VAR*TRT	9	45	0.47	0.8891

Effect=TRT Method=Tukey-Kramer(P<0.05) Set=1

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
1		D	14.6375	0.2438	A
2		A	14.5500	0.2438	A
3		C	14.5375	0.2438	A
4		B	14.2688	0.2438	A

Effect=VAR Method=Tukey-Kramer(P<0.05) Set=2

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
5	845		16.9125	0.2438	A
6	555		14.1813	0.2438	B
7	321		13.6688	0.2438	BC
8	384		13.2313	0.2438	C

Effect=VAR*TRT Method=Tukey-Kramer(P<0.05) Set=3

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
9	845	D	17.4000	0.4476	A
10	845	C	17.1000	0.4476	A
11	845	A	16.9500	0.4476	A
12	845	B	16.2000	0.4476	AB
13	555	A	14.4500	0.4476	BC
14	555	D	14.4000	0.4476	BC
15	555	B	13.9500	0.4476	C
16	555	C	13.9250	0.4476	C
17	321	C	13.8500	0.4476	C
18	321	A	13.6750	0.4476	C
19	321	B	13.6250	0.4476	C
20	321	D	13.5250	0.4476	C
21	384	B	13.3000	0.4476	C
22	384	C	13.2750	0.4476	C
23	384	D	13.2250	0.4476	C
24	384	A	13.1250	0.4476	C

The Mixed Procedure

Model Information

Data Set	WORK.SUGAR
Dependent Variable	FIB2
Covariance Structure	Variance Components
Estimation Method	Type 3
Residual Variance Method	Factor
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Satterthwaite

Class Level Information

Class	Levels	Values
REP	4	1 2 3 4
VAR	4	321 384 555 845
TRT	4	A B C D

Dimensions

Covariance Parameters	2
Columns in X	25
Columns in Z	4
Subjects	1
Max Obs Per Subject	64
Observations Used	64
Observations Not Used	0
Total Observations	64

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
VAR	3	151.572969	50.524323	Var(Residual) + Q(VAR,VAR*TRT)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
VAR	MS(Residual)	45	54.68	<.0001

The Mixed Procedure

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
TRT	3	5.955469	1.985156	Var(Residual) + Q(TRT,VAR*TRT)
VAR*TRT	9	2.545156	0.282795	Var(Residual) + Q(VAR*TRT)
REP	3	1.871719	0.623906	Var(Residual) + 16 Var(REP)
Residual	45	41.580781	0.924017	Var(Residual)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
TRT	MS(Residual)	45	2.15	0.1074
VAR*TRT	MS(Residual)	45	0.31	0.9690
REP	MS(Residual)	45	0.68	0.5718
Residual	.	.	.	.

Covariance Parameter Estimates

Cov Parm	Estimate
REP	-0.01876
Residual	0.9240

Fit Statistics

-2 Res Log Likelihood	153.4
AIC (smaller is better)	157.4
AICC (smaller is better)	157.7
BIC (smaller is better)	156.2

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F

VAR	3	45	54.68	<.0001
TRT	3	45	2.15	0.1074
VAR*TRT	9	45	0.31	0.9690

Effect=TRT   Method=Tukey-Kramer(P<0.05)   Set=1

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
1		D	13.5062	0.2304	A
2		C	13.4312	0.2304	A
3		A	13.0937	0.2304	A
4		B	12.7375	0.2304	A

Effect=VAR   Method=Tukey-Kramer(P<0.05)   Set=2

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
5	845		15.7500	0.2304	A
6	555		13.0437	0.2304	B
7	384		12.0437	0.2304	C
8	321		11.9312	0.2304	C

Effect=VAR*TRT   Method=Tukey-Kramer(P<0.05)   Set=3

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
9	845	D	16.2000	0.4757	A
10	845	A	15.9250	0.4757	A
11	845	C	15.9000	0.4757	AB
12	845	B	14.9750	0.4757	ABC
13	555	D	13.4500	0.4757	BCD
14	555	C	13.1000	0.4757	CD
15	555	A	12.8250	0.4757	CD
16	555	B	12.8000	0.4757	CD
17	321	C	12.4000	0.4757	D
18	384	C	12.3250	0.4757	D
19	384	D	12.2500	0.4757	D
20	384	A	12.1500	0.4757	D
21	321	D	12.1250	0.4757	D
22	321	B	11.7250	0.4757	D
23	321	A	11.4750	0.4757	D
24	384	B	11.4500	0.4757	D

The Mixed Procedure

Model Information

Data Set	WORK.SUGAR
Dependent Variable	FIB3
Covariance Structure	Variance Components
Estimation Method	Type 3
Residual Variance Method	Factor
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Satterthwaite

Class Level Information

Class	Levels	Values
REP	4	1 2 3 4
VAR	4	321 384 555 845
TRT	4	A B C D

Dimensions

Covariance Parameters	2

Columns in X	25
Columns in Z	4
Subjects	1
Max Obs Per Subject	64
Observations Used	64
Observations Not Used	0
Total Observations	64

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
VAR	3	68.650625	22.883542	Var(Residual) + Q(VAR,VAR*TRT)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
VAR	MS(Residual)	45	19.41	<.0001

The Mixed Procedure

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
TRT	3	8.223125	2.741042	Var(Residual) + Q(TRT,VAR*TRT)
VAR*TRT	9	6.855625	0.761736	Var(Residual) + Q(VAR*TRT)
REP	3	1.383125	0.461042	Var(Residual) + 16 Var(REP)
Residual	45	53.046875	1.178819	Var(Residual)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
TRT	MS(Residual)	45	2.33	0.0875
VAR*TRT	MS(Residual)	45	0.65	0.7516
REP	MS(Residual)	45	0.39	0.7600
Residual	.	.	.	.

Covariance Parameter Estimates

Cov Parm	Estimate
REP	-0.04486
Residual	1.1788

Fit Statistics

-2 Res Log Likelihood	163.5
AIC (smaller is better)	167.5
AICC (smaller is better)	167.7
BIC (smaller is better)	166.3

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
VAR	3	45	19.41	<.0001
TRT	3	45	2.33	0.0875
VAR*TRT	9	45	0.65	0.7516

Effect=TRT   Method=Tukey-Kramer(P<0.05)   Set=1

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
1		C	12.9437	0.2499	A

2		D	12.3125	0.2499	A
3		A	12.1563	0.2499	A
4		B	12.0000	0.2499	A

Effect=VAR   Method=Tukey-Kramer(P<0.05)   Set=2

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
5	845		14.0750	0.2499	A
6	384		12.2500	0.2499	B
7	321		11.5937	0.2499	B
8	555		11.4938	0.2499	B

Effect=VAR*TRT   Method=Tukey-Kramer(P<0.05)   Set=3

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
9	845	C	14.5000	0.5324	A
10	845	D	14.4000	0.5324	A
11	845	A	14.0750	0.5324	AB
12	845	B	13.3250	0.5324	ABC
13	384	C	12.6500	0.5324	ABC
14	555	C	12.6000	0.5324	ABC
15	384	D	12.4250	0.5324	ABC
16	384	A	12.1750	0.5324	ABC
17	321	C	12.0250	0.5324	ABC
18	321	D	11.7750	0.5324	ABC
19	384	B	11.7500	0.5324	ABC
20	321	B	11.5000	0.5324	BC
21	555	B	11.4250	0.5324	BC
22	555	A	11.3000	0.5324	BC
23	321	A	11.0750	0.5324	C
24	555	D	10.6500	0.5324	C

The Mixed Procedure

Model Information

Data Set	WORK.SUGAR
Dependent Variable	FIB
Covariance Structure	Variance Components
Estimation Method	Type 3
Residual Variance Method	Factor
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Satterthwaite

Class Level Information

Class	Levels	Values
REP	4	1 2 3 4
VAR	4	321 384 555 845
TRT	4	A B C D

Dimensions

Covariance Parameters	2
Columns in X	25
Columns in Z	4
Subjects	1
Max Obs Per Subject	64
Observations Used	64
Observations Not Used	0
Total Observations	64

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
VAR	3	108.495139	36.165046	Var(Residual) + Q(VAR,VAR*TRT)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
VAR	MS(Residual)	45	50.01	<.0001

The Mixed Procedure

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
TRT	3	3.663472	1.221157	Var(Residual) + Q(TRT,VAR*TRT)
VAR*TRT	9	1.853889	0.205988	Var(Residual) + Q(VAR*TRT)
REP	3	2.047639	0.682546	Var(Residual) + 16 Var(REP)
Residual	45	32.544028	0.723201	Var(Residual)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
TRT	MS(Residual)	45	1.69	0.1829
VAR*TRT	MS(Residual)	45	0.28	0.9756
REP	MS(Residual)	45	0.94	0.4275
Residual	.	.	.	.

Covariance Parameter Estimates

Cov Parm	Estimate
REP	-0.00254
Residual	0.7232

Fit Statistics

-2 Res Log Likelihood	142.7
AIC (smaller is better)	146.7
AICC (smaller is better)	146.9
BIC (smaller is better)	145.4

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
VAR	3	45	50.01	<.0001
TRT	3	45	1.69	0.1829
VAR*TRT	9	45	0.28	0.9756

Effect=TRT Method=Tukey-Kramer(P<0.05) Set=1

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
1		C	13.6375	0.2111	A
2		D	13.4854	0.2111	A
3		A	13.2667	0.2111	A
4		B	13.0021	0.2111	A

Effect=VAR   Method=Tukey-Kramer(P<0.05)   Set=2

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
5	845		15.5792	0.2111	A
6	555		12.9062	0.2111	B
7	384		12.5083	0.2111	B
8	321		12.3979	0.2111	B

Effect=VAR*TRT   Method=Tukey-Kramer(P<0.05)   Set=3

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
9	845	D	16.0000	0.4245	A
10	845	C	15.8333	0.4245	A
11	845	A	15.6500	0.4245	A
12	845	B	14.8333	0.4245	AB
13	555	C	13.2083	0.4245	BC
14	555	A	12.8583	0.4245	BC
15	555	D	12.8333	0.4245	BC
16	321	C	12.7583	0.4245	BC
17	384	C	12.7500	0.4245	BC
18	555	B	12.7250	0.4245	BC
19	384	D	12.6333	0.4245	C
20	384	A	12.4833	0.4245	C
21	321	D	12.4750	0.4245	C
22	321	B	12.2833	0.4245	C
23	384	B	12.1667	0.4245	C
24	321	A	12.0750	0.4245	C

The Mixed Procedure

Model Information

Data Set	WORK.SUGAR
Dependent Variable	TRS1
Covariance Structure	Variance Components
Estimation Method	Type 3
Residual Variance Method	Factor
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Satterthwaite

Class Level Information

Class	Levels	Values
REP	4	1 2 3 4
VAR	4	321 384 555 845
TRT	4	A B C D

Dimensions

Covariance Parameters	2
Columns in X	25
Columns in Z	4
Subjects	1
Max Obs Per Subject	64
Observations Used	64
Observations Not Used	0
Total Observations	64

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
VAR	3	7651.045000	2550.348333	Var(Residual) + Q(VAR,VAR*TRT)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
VAR	MS(Residual)	45	20.75	<.0001

The Mixed Procedure

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
TRT	3	1192.078750	397.359583	Var(Residual) + Q(TRT,VAR*TRT)
VAR*TRT	9	356.331250	39.592361	Var(Residual) + Q(VAR*TRT)
REP	3	403.783750	134.594583	Var(Residual) + 16 Var(REP)
Residual	45	5530.021250	122.889361	Var(Residual)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
TRT	MS(Residual)	45	3.23	0.0309
VAR*TRT	MS(Residual)	45	0.32	0.9634
REP	MS(Residual)	45	1.10	0.3609
Residual	.	.	.	.

Covariance Parameter Estimates

Cov Parm	Estimate
REP	0.7316
Residual	122.89

Fit Statistics

-2 Res Log Likelihood	389.6
AIC (smaller is better)	393.6
AICC (smaller is better)	393.9
BIC (smaller is better)	392.4

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
VAR	3	45	20.75	<.0001
TRT	3	45	3.23	0.0309
VAR*TRT	9	45	0.32	0.9634

Effect=TRT Method=Tukey-Kramer(P<0.05) Set=1

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
1		B	260.91	2.8042	A
2		D	260.18	2.8042	AB
3		A	259.59	2.8042	AB
4		C	250.32	2.8042	B

Effect=VAR Method=Tukey-Kramer(P<0.05) Set=2

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
5	384		270.23	2.8042	A
6	555		266.54	2.8042	A
7	321		250.23	2.8042	B
8	845		244.01	2.8042	B

Effect=VAR*TRT Method=Tukey-Kramer(P<0.05) Set=3

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
9	384	D	274.23	5.5592	A
10	555	B	272.65	5.5592	AB
11	384	A	271.45	5.5592	AB
12	384	B	271.33	5.5592	AB
13	555	D	269.68	5.5592	ABC
14	555	A	268.88	5.5592	ABC
15	384	C	263.90	5.5592	ABCD
16	555	C	254.95	5.5592	ABCD
17	321	D	254.38	5.5592	ABCD
18	321	B	252.40	5.5592	ABCD
19	845	A	249.52	5.5592	ABCD
20	321	A	248.53	5.5592	ABCD
21	845	B	247.27	5.5592	ABCD
22	321	C	245.60	5.5592	BCD
23	845	D	242.43	5.5592	CD
24	845	C	236.83	5.5592	D

The Mixed Procedure

Model Information

Data Set	WORK.SUGAR
Dependent Variable	TRS2
Covariance Structure	Variance Components
Estimation Method	Type 3
Residual Variance Method	Factor
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Satterthwaite

Class Level Information

Class	Levels	Values
REP	4	1 2 3 4
VAR	4	321 384 555 845
TRT	4	A B C D

Dimensions

Covariance Parameters	2
Columns in X	25
Columns in Z	4
Subjects	1
Max Obs Per Subject	64
Observations Used	64
Observations Not Used	0
Total Observations	64

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
VAR	3	5611.388750	1870.462917	Var(Residual) + Q(VAR,VAR*TRT)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
VAR	MS(Residual)	45	9.30	<.0001

The Mixed Procedure

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
TRT	3	3476.501250	1158.833750	Var(Residual) + Q(TRT,VAR*TRT)
VAR*TRT	9	935.917500	103.990833	Var(Residual) + Q(VAR*TRT)
REP	3	1039.038750	346.346250	Var(Residual) + 16 Var(REP)
Residual	45	9045.991250	201.022028	Var(Residual)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
TRT	MS(Residual)	45	5.76	0.0020
VAR*TRT	MS(Residual)	45	0.52	0.8542
REP	MS(Residual)	45	1.72	0.1758
Residual	.	.	.	.

Covariance Parameter Estimates

Cov Parm	Estimate
REP	9.0828
Residual	201.02

Fit Statistics

-2 Res Log Likelihood	414.6
AIC (smaller is better)	418.6
AICC (smaller is better)	418.9
BIC (smaller is better)	417.4

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
VAR	3	45	9.30	<.0001
TRT	3	45	5.76	0.0020
VAR*TRT	9	45	0.52	0.8542

Effect=TRT Method=Tukey-Kramer(P<0.05) Set=1

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
1		A	267.49	3.8516	A
2		B	265.56	3.8516	A
3		D	264.02	3.8516	A
4		C	248.91	3.8516	B

Effect=VAR Method=Tukey-Kramer(P<0.05) Set=2

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
5	555		272.09	3.8516	A
6	384		267.11	3.8516	A
7	321		259.53	3.8516	AB
8	845		247.24	3.8516	B

Effect=VAR*TRT Method=Tukey-Kramer(P<0.05) Set=3

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
9	555	A	284.60	7.2475	A
10	555	D	278.10	7.2475	A
11	384	B	275.40	7.2475	A
12	555	B	274.67	7.2475	A
13	384	A	270.57	7.2475	AB

14	384	D	265.17	7.2475	AB
15	321	B	263.12	7.2475	AB
16	321	D	261.60	7.2475	AB
17	321	A	261.30	7.2475	AB
18	384	C	257.30	7.2475	AB
19	845	A	253.47	7.2475	AB
20	321	C	252.10	7.2475	AB
21	845	D	251.22	7.2475	AB
22	555	C	250.97	7.2475	AB
23	845	B	249.02	7.2475	AB
24	845	C	235.25	7.2475	B

The Mixed Procedure

Model Information

Data Set	WORK.SUGAR
Dependent Variable	TRS3
Covariance Structure	Variance Components
Estimation Method	Type 3
Residual Variance Method	Factor
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Satterthwaite

Class Level Information

Class	Levels	Values
REP	4	1 2 3 4
VAR	4	321 384 555 845
TRT	4	A B C D

Dimensions

Covariance Parameters	2
Columns in X	25
Columns in Z	4
Subjects	1
Max Obs Per Subject	64
Observations Used	64
Observations Not Used	0
Total Observations	64

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
VAR	3	6052.508750	2017.502917	Var(Residual) + Q(VAR,VAR*TRT)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
VAR	MS(Residual)	45	3.89	0.0149

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Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
TRT	3	9489.608750	3163.202917	Var(Residual) + Q(TRT,VAR*TRT)
VAR*TRT	9	4958.317500	550.924167	Var(Residual) + Q(VAR*TRT)
REP	3	4214.628750	1404.876250	Var(Residual) + 16 Var(REP)
Residual	45	23363	519.181917	Var(Residual)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
TRT	MS(Residual)	45	6.09	0.0014
VAR*TRT	MS(Residual)	45	1.06	0.4091
REP	MS(Residual)	45	2.71	0.0564
Residual	.	.	.	.

Covariance Parameter Estimates

Cov Parm	Estimate
REP	55.3559
Residual	519.18

Fit Statistics

-2 Res Log Likelihood	461.5
AIC (smaller is better)	465.5
AICC (smaller is better)	465.8
BIC (smaller is better)	464.3

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
VAR	3	45	3.89	0.0149
TRT	3	45	6.09	0.0014
VAR*TRT	9	45	1.06	0.4091

Effect=TRT Method=Tukey-Kramer(P<0.05) Set=1

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
1		D	240.78	6.8035	A
2		A	235.26	6.8035	A
3		B	230.90	6.8035	A
4		C	208.71	6.8035	B

Effect=VAR Method=Tukey-Kramer(P<0.05) Set=2

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
5	555		242.62	6.8035	A
6	384		233.21	6.8035	AB
7	321		222.13	6.8035	AB
8	845		217.69	6.8035	B

Effect=VAR*TRT Method=Tukey-Kramer(P<0.05) Set=3

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
9	555	D	266.10	11.9848	A
10	384	A	254.45	11.9848	AB
11	555	A	250.43	11.9848	AB
12	555	B	240.22	11.9848	AB
13	384	B	237.03	11.9848	AB
14	845	D	235.82	11.9848	AB
15	321	B	235.30	11.9848	AB
16	384	D	233.00	11.9848	AB
17	321	D	228.20	11.9848	AB
18	845	A	222.93	11.9848	AB
19	555	C	213.73	11.9848	AB
20	321	A	213.22	11.9848	AB
21	321	C	211.78	11.9848	AB

22	845	B	211.05	11.9848	AB
23	384	C	208.38	11.9848	AB
24	845	C	200.97	11.9848	B

The Mixed Procedure

Model Information

Data Set	WORK.SUGAR
Dependent Variable	TRS
Covariance Structure	Variance Components
Estimation Method	Type 3
Residual Variance Method	Factor
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Satterthwaite

Class Level Information

Class	Levels	Values
REP	4	1 2 3 4
VAR	4	321 384 555 845
TRT	4	A B C D

Dimensions

Covariance Parameters	2
Columns in X	25
Columns in Z	4
Subjects	1
Max Obs Per Subject	64
Observations Used	64
Observations Not Used	0
Total Observations	64

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
VAR	3	6041.365972	2013.788657	Var(Residual) + Q(VAR,VAR*TRT)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
VAR	MS(Residual)	45	9.62	<.0001

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Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
TRT	3	3887.300417	1295.766806	Var(Residual) + Q(TRT,VAR*TRT)
VAR*TRT	9	1015.460000	112.828889	Var(Residual) + Q(VAR*TRT)
REP	3	1399.192500	466.397500	Var(Residual) + 16 Var(REP)
Residual	45	9422.451944	209.387821	Var(Residual)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
TRT	MS(Residual)	45	6.19	0.0013
VAR*TRT	MS(Residual)	45	0.54	0.8383
REP	MS(Residual)	45	2.23	0.0980
Residual	.	.	.	.

Covariance Parameter
Estimates

Cov Parm	Estimate
REP	16.0631
Residual	209.39

Fit Statistics

-2 Res Log Likelihood	417.3
AIC (smaller is better)	421.3
AICC (smaller is better)	421.6
BIC (smaller is better)	420.1

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
VAR	3	45	9.62	<.0001
TRT	3	45	6.19	0.0013
VAR*TRT	9	45	0.54	0.8383

Effect=TRT Method=Tukey-Kramer(P<0.05) Set=1

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
1		D	254.99	4.1355	A
2		A	254.11	4.1355	A
3		B	252.46	4.1355	A
4		C	235.98	4.1355	B

Effect=VAR Method=Tukey-Kramer(P<0.05) Set=2

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
5	555		260.41	4.1355	A
6	384		256.85	4.1355	AB
7	321		243.96	4.1355	BC
8	845		236.32	4.1355	C

Effect=VAR*TRT Method=Tukey-Kramer(P<0.05) Set=3

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
9	555	D	271.29	7.5075	A
10	555	A	267.97	7.5075	A
11	384	A	265.49	7.5075	A
12	555	B	262.52	7.5075	A
13	384	B	261.25	7.5075	AB
14	384	D	257.47	7.5075	AB
15	321	B	250.28	7.5075	AB
16	321	D	248.06	7.5075	AB
17	384	C	243.19	7.5075	AB
18	845	D	243.16	7.5075	AB
19	845	A	241.98	7.5075	AB
20	321	A	241.02	7.5075	AB
21	555	C	239.88	7.5075	AB
22	321	C	236.49	7.5075	AB
23	845	B	235.78	7.5075	AB
24	845	C	224.35	7.5075	B

The Mixed Procedure

Model Information

Data Set	WORK.SUGAR
Dependent Variable	TONS
Covariance Structure	Variance Components

```
Estimation Method            Type 3
Residual Variance Method     Factor
Fixed Effects SE Method      Model-Based
Degrees of Freedom Method    Satterthwaite

             Class Level Information
Class    Levels    Values
REP           4    1 2 3 4
VAR           4    321 384 555 845
TRT           4    A B C D

            Dimensions
Covariance Parameters            2
Columns in X                    25
Columns in Z                     4
Subjects                         1
Max Obs Per Subject             64
Observations Used               64
Observations Not Used            0
Total Observations              64

                         Type 3 Analysis of Variance
                        Sum of
Source        DF       Squares   Mean Square  Expected Mean Square
VAR            3    104.062500     34.687500  Var(Residual) + Q(VAR,VAR*TRT)

                        Type 3 Analysis of Variance
                                                   Error
Source    Error Term                                  DF    F Value    Pr > F
VAR       MS(Residual)                                45       1.03    0.3893

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                         Type 3 Analysis of Variance
                        Sum of
Source        DF       Squares   Mean Square  Expected Mean Square
TRT            3     39.062500     13.020833  Var(Residual) + Q(TRT,VAR*TRT)
VAR*TRT        9    167.812500     18.645833  Var(Residual) + Q(VAR*TRT)
REP            3    603.187500    201.062500  Var(Residual) + 16 Var(REP)
Residual      45   1518.812500     33.751389  Var(Residual)

                        Type 3 Analysis of Variance
                                                   Error
Source    Error Term                                  DF    F Value    Pr > F
TRT       MS(Residual)                                45       0.39    0.7637
VAR*TRT   MS(Residual)                                45       0.55    0.8279
REP       MS(Residual)                                45       5.96    0.0016
Residual  .                                            .        .        .

Covariance Parameter
      Estimates
Cov Parm     Estimate
REP           10.4569
Residual      33.7514

           Fit Statistics
-2 Res Log Likelihood          332.7
AIC (smaller is better)        336.7
AICC (smaller is better)       336.9
```

BIC (smaller is better) 335.4

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
VAR	3	45	1.03	0.3893
TRT	3	45	0.39	0.7637
VAR*TRT	9	45	0.55	0.8279

Effect=TRT Method=Tukey-Kramer(P<0.05) Set=1

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
1		B	31.8750	2.1734	A
2		D	30.9375	2.1734	A
3		A	30.6250	2.1734	A
4		C	29.6875	2.1734	A

Effect=VAR Method=Tukey-Kramer(P<0.05) Set=2

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
5	384		32.3125	2.1734	A
6	321		31.7500	2.1734	A
7	845		29.7500	2.1734	A
8	555		29.3125	2.1734	A

Effect=VAR*TRT Method=Tukey-Kramer(P<0.05) Set=3

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
9	321	B	34.5000	3.3245	A
10	384	D	34.5000	3.3245	A
11	321	C	32.7500	3.3245	A
12	555	A	32.7500	3.3245	A
13	384	A	32.2500	3.3245	A
14	384	B	31.7500	3.3245	A
15	845	B	31.7500	3.3245	A
16	321	D	30.7500	3.3245	A
17	384	C	30.7500	3.3245	A
18	845	D	30.0000	3.3245	A
19	555	B	29.5000	3.3245	A
20	321	A	29.0000	3.3245	A
21	845	C	28.7500	3.3245	A
22	555	D	28.5000	3.3245	A
23	845	A	28.5000	3.3245	A
24	555	C	26.5000	3.3245	A

The Mixed Procedure

Model Information

Data Set	WORK.SUGAR
Dependent Variable	LBS
Covariance Structure	Variance Components
Estimation Method	Type 3
Residual Variance Method	Factor
Fixed Effects SE Method	Model-Based
Degrees of Freedom Method	Satterthwaite

Class Level Information

Class	Levels	Values
REP	4	1 2 3 4

VAR	4	321 384 555 845
TRT	4	A B C D

Dimensions	
Covariance Parameters	2
Columns in X	25
Columns in Z	4
Subjects	1
Max Obs Per Subject	64
Observations Used	64
Observations Not Used	0
Total Observations	64

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
VAR	3	14311326	4770442	Var(Residual) + Q(VAR,VAR*TRT)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
VAR	MS(Residual)	45	2.48	0.0734

The Mixed Procedure

Type 3 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	Expected Mean Square
TRT	3	10018092	3339364	Var(Residual) + Q(TRT,VAR*TRT)
VAR*TRT	9	12318606	1368734	Var(Residual) + Q(VAR*TRT)
REP	3	26898221	8966074	Var(Residual) + 16 Var(REP)
Residual	45	86663657	1925859	Var(Residual)

Type 3 Analysis of Variance

Source	Error Term	Error DF	F Value	Pr > F
TRT	MS(Residual)	45	1.73	0.1735
VAR*TRT	MS(Residual)	45	0.71	0.6960
REP	MS(Residual)	45	4.66	0.0064
Residual	.	.	.	.

Covariance Parameter Estimates

Cov Parm	Estimate
REP	440013
Residual	1925859

Fit Statistics	
-2 Res Log Likelihood	857.6
AIC (smaller is better)	861.6
AICC (smaller is better)	861.9
BIC (smaller is better)	860.4

Type 3 Tests of Fixed Effects

Effect	Num DF	Den DF	F Value	Pr > F
VAR	3	45	2.48	0.0734
TRT	3	45	1.73	0.1735
VAR*TRT	9	45	0.71	0.6960

Effect=TRT Method=Tukey-Kramer(P<0.05) Set=1

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
1		B	8020.00	479.97	A
2		D	7864.38	479.97	A
3		A	7761.44	479.97	A
4		C	6993.31	479.97	A

Effect=VAR Method=Tukey-Kramer(P<0.05) Set=2

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
5	384		8287.50	479.97	A
6	321		7717.56	479.97	AB
7	555		7679.06	479.97	AB
8	845		6955.00	479.97	B

Effect=VAR*TRT Method=Tukey-Kramer(P<0.05) Set=3

Obs	VAR	TRT	Estimate	Standard Error	Letter Group
9	384	D	8891.75	769.07	A
10	321	B	8632.75	769.07	A
11	384	A	8547.25	769.07	A
12	555	B	8252.25	769.07	A
13	384	B	8231.00	769.07	A
14	555	D	8069.75	769.07	A
15	845	A	7974.75	769.07	A
16	321	C	7626.25	769.07	A
17	321	D	7613.25	769.07	A
18	555	A	7525.75	769.07	A
19	384	C	7480.00	769.07	A
20	321	A	6998.00	769.07	A
21	845	B	6964.00	769.07	A
22	845	D	6882.75	769.07	A
23	555	C	6868.50	769.07	A
24	845	C	5998.50	769.07	A

APPENDIX F: 2001 SUGARCANE ECONOMIC THRESHOLD SAS PROGRAM

```
dm'log;clear'; dm'output;clear';
options nodate nocenter pageno=1 ps=50 ls=78;
DATA SUGAR; INFILE CARDS MISSOVER;
INPUT NUM$ YEAR$ VAR$ TRT$ REP$ FIB TRS BOR1 BOR2 BOR3 LBS SW TONS;
BOR = (BOR1 + BOR2 + BOR3);
CARDS;
;
PROC SORT DATA=SUGAR;
BY YEAR VAR TRT REP;
RUN;
PROC PRINT DATA=SUGAR;
RUN;
PROC MEANS MEAN NOPRINT;
VAR BOR1 BOR2 BOR3 BOR SW FIB TRS TONS LBS;
OUTPUT OUT=FRED MEAN =;
PROC PRINT;
VAR BOR1 BOR2 BOR3 BOR SW FIB TRS TONS LBS;
RUN;
PROC MIXED data=SUGAR method=type3;
CLASSES REP VAR TRT;
MODEL BOR1 = VAR TRT VAR*TRT /HTYPE=3 DDFM = SATTERTHWAITE OUTP=SUGAR2;
RANDOM REP;
LSMEANS TRT VAR VAR*TRT  / PDIFF ADJUST = TUKEY;
ODS OUTPUT DIFFS=PPP;
ODS OUTPUT LSMEANS=MMM;
ODS LISTING EXCLUDE DIFFS;
ODS LISTING EXCLUDE LSMEANS;
RUN;
%INCLUDE 'C:\PDMIX800.SAS';
%PDMIX800 (PPP, MMM, ALPHA=0.05, SORT=YES);
RUN;
QUIT;
PROC MIXED data=SUGAR method=type3;
CLASSES REP VAR TRT;
MODEL BOR2 = VAR TRT VAR*TRT /HTYPE=3 DDFM = SATTERTHWAITE OUTP=SUGAR2;
RANDOM REP;
LSMEANS TRT VAR VAR*TRT  / PDIFF ADJUST = TUKEY;
ODS OUTPUT DIFFS=PPP;
ODS OUTPUT LSMEANS=MMM;
ODS LISTING EXCLUDE DIFFS;
ODS LISTING EXCLUDE LSMEANS;
RUN;
%INCLUDE 'C:\PDMIX800.SAS';
%PDMIX800 (PPP, MMM, ALPHA=0.05, SORT=YES);
RUN;
QUIT;
PROC MIXED data=SUGAR method=type3;
CLASSES REP VAR TRT;
MODEL BOR3 = VAR TRT VAR*TRT /HTYPE=3 DDFM = SATTERTHWAITE OUTP=SUGAR2;
RANDOM REP;
LSMEANS TRT VAR VAR*TRT  / PDIFF ADJUST = TUKEY;
ODS OUTPUT DIFFS=PPP;
ODS OUTPUT LSMEANS=MMM;
ODS LISTING EXCLUDE DIFFS;
ODS LISTING EXCLUDE LSMEANS;
RUN;
```

```
%INCLUDE 'C:\PDMIX800.SAS';
%PDMIX800 (PPP, MMM, ALPHA=0.05, SORT=YES);
RUN;
QUIT;
PROC MIXED data=SUGAR method=type3;
CLASSES REP VAR TRT;
MODEL BOR = VAR TRT VAR*TRT /HTYPE=3 DDFM = SATTERTHWAITE OUTP=SUGAR2;
RANDOM REP;
LSMEANS TRT VAR VAR*TRT  / PDIFF ADJUST = TUKEY;
ODS OUTPUT DIFFS=PPP;
ODS OUTPUT LSMEANS=MMM;
ODS LISTING EXCLUDE DIFFS;
ODS LISTING EXCLUDE LSMEANS;
RUN;
%INCLUDE 'C:\PDMIX800.SAS';
%PDMIX800 (PPP, MMM, ALPHA=0.05, SORT=YES);
RUN;
QUIT;
PROC MIXED data=SUGAR method=type3;
CLASSES REP VAR TRT;
MODEL SW = VAR TRT VAR*TRT /HTYPE=3 DDFM = SATTERTHWAITE OUTP=SUGAR2;
RANDOM REP;
LSMEANS TRT VAR VAR*TRT  / PDIFF ADJUST = TUKEY;
ODS OUTPUT DIFFS=PPP;
ODS OUTPUT LSMEANS=MMM;
ODS LISTING EXCLUDE DIFFS;
ODS LISTING EXCLUDE LSMEANS;
RUN;
%INCLUDE 'C:\PDMIX800.SAS';
%PDMIX800 (PPP, MMM, ALPHA=0.05, SORT=YES);
RUN;
QUIT;
PROC MIXED data=SUGAR method=type3;
CLASSES REP VAR TRT;
MODEL FIB = VAR TRT VAR*TRT /HTYPE=3 DDFM = SATTERTHWAITE OUTP=SUGAR2;
RANDOM REP;
LSMEANS TRT VAR VAR*TRT  / PDIFF ADJUST = TUKEY;
ODS OUTPUT DIFFS=PPP;
ODS OUTPUT LSMEANS=MMM;
ODS LISTING EXCLUDE DIFFS;
ODS LISTING EXCLUDE LSMEANS;
RUN;
%INCLUDE 'C:\PDMIX800.SAS';
%PDMIX800 (PPP, MMM, ALPHA=0.05, SORT=YES);
RUN;
QUIT;
PROC MIXED data=SUGAR method=type3;
CLASSES REP VAR TRT;
MODEL TRS = VAR TRT VAR*TRT /HTYPE=3 DDFM = SATTERTHWAITE OUTP=SUGAR2;
RANDOM REP;
LSMEANS TRT VAR VAR*TRT  / PDIFF ADJUST = TUKEY;
ODS OUTPUT DIFFS=PPP;
ODS OUTPUT LSMEANS=MMM;
ODS LISTING EXCLUDE DIFFS;
ODS LISTING EXCLUDE LSMEANS;
RUN;
%INCLUDE 'C:\PDMIX800.SAS';
%PDMIX800 (PPP, MMM, ALPHA=0.05, SORT=YES);
```

```
RUN;
QUIT;
PROC MIXED data=SUGAR method=type3;
CLASSES REP VAR TRT;
MODEL TONS = VAR TRT VAR*TRT /HTYPE=3 DDFM = SATTERTHWAITE OUTP=SUGAR2;
RANDOM REP;
LSMEANS TRT VAR VAR*TRT  / PDIFF ADJUST = TUKEY;
ODS OUTPUT DIFFS=PPP;
ODS OUTPUT LSMEANS=MMM;
ODS LISTING EXCLUDE DIFFS;
ODS LISTING EXCLUDE LSMEANS;
RUN;
%INCLUDE 'C:\PDMIX800.SAS';
%PDMIX800 (PPP, MMM, ALPHA=0.05, SORT=YES);
RUN;
QUIT;
PROC MIXED data=SUGAR method=type3;
CLASSES REP VAR TRT;
MODEL LBS = VAR TRT VAR*TRT /HTYPE=3 DDFM = SATTERTHWAITE OUTP=SUGAR2;
RANDOM REP;
LSMEANS TRT VAR VAR*TRT  / PDIFF ADJUST = TUKEY;
ODS OUTPUT DIFFS=PPP;
ODS OUTPUT LSMEANS=MMM;
ODS LISTING EXCLUDE DIFFS;
ODS LISTING EXCLUDE LSMEANS;
RUN;
%INCLUDE 'C:\PDMIX800.SAS';
%PDMIX800 (PPP, MMM, ALPHA=0.05, SORT=YES);
RUN;
QUIT;
```

APPENDIX G: 2002 SUGARCANE ECONOMIC THRESHOLD SAS PROGRAM

```
dm'log;clear'; dm'output;clear';
options nodate nocenter pageno=1 ps=50 ls=78;
DATA SUGAR; INFILE CARDS MISSOVER;
INPUT NUM$ VAR$ YEAR$ TRT$ REP$ FIB1 FIB2 FIB3 TRS1 TRS2 TRS3 BOR1 BOR2 BOR3 LBS SW TONS;
BOR = (BOR1 + BOR2 + BOR3);
FIB = (FIB1 + FIB2 + FIB3) / 3;
TRS = (TRS1 + TRS2 + TRS3) / 3;
CARDS;
;
PROC SORT DATA=SUGAR;
BY YEAR VAR TRT REP;
RUN;
PROC PRINT DATA=SUGAR;
RUN;
PROC MEANS MEAN NOPRINT;
VAR BOR1 BOR2 BOR3 BOR SW FIB1 FIB2 FIB3 FIB TRS1 TRS2 TRS3 TRS TONS LBS;
OUTPUT OUT=FRED MEAN =;
PROC PRINT;
VAR BOR1 BOR2 BOR3 BOR SW FIB1 FIB2 FIB3 FIB TRS1 TRS2 TRS3 TRS TONS LBS;
RUN;
PROC MIXED data=SUGAR method=type3;
CLASSES REP VAR TRT;
MODEL BOR1 = VAR TRT VAR*TRT /HTYPE=3 DDFM = SATTERTHWAITE OUTP=SUGAR2;
RANDOM REP;
LSMEANS TRT VAR VAR*TRT  / PDIFF ADJUST = TUKEY;
ODS OUTPUT DIFFS=PPP;
ODS OUTPUT LSMEANS=MMM;
ODS LISTING EXCLUDE DIFFS;
ODS LISTING EXCLUDE LSMEANS;
RUN;
%INCLUDE 'C:\PDMIX800.SAS';
%PDMIX800 (PPP, MMM, ALPHA=0.05, SORT=YES);
RUN;
QUIT;
PROC MIXED data=SUGAR method=type3;
CLASSES REP VAR TRT;
MODEL BOR2 = VAR TRT VAR*TRT /HTYPE=3 DDFM = SATTERTHWAITE OUTP=SUGAR2;
RANDOM REP;
LSMEANS TRT VAR VAR*TRT  / PDIFF ADJUST = TUKEY;
ODS OUTPUT DIFFS=PPP;
ODS OUTPUT LSMEANS=MMM;
ODS LISTING EXCLUDE DIFFS;
ODS LISTING EXCLUDE LSMEANS;
RUN;
%INCLUDE 'C:\PDMIX800.SAS';
%PDMIX800 (PPP, MMM, ALPHA=0.05, SORT=YES);
RUN;
QUIT;
PROC MIXED data=SUGAR method=type3;
CLASSES REP VAR TRT;
MODEL BOR3 = VAR TRT VAR*TRT /HTYPE=3 DDFM = SATTERTHWAITE OUTP=SUGAR2;
RANDOM REP;
LSMEANS TRT VAR VAR*TRT  / PDIFF ADJUST = TUKEY;
ODS OUTPUT DIFFS=PPP;
ODS OUTPUT LSMEANS=MMM;
ODS LISTING EXCLUDE DIFFS;
```

```
ODS LISTING EXCLUDE LSMEANS;
RUN;
%INCLUDE 'C:\PDMIX800.SAS';
%PDMIX800 (PPP, MMM, ALPHA=0.05, SORT=YES);
RUN;
QUIT;
PROC MIXED data=SUGAR method=type3;
CLASSES REP VAR TRT;
MODEL BOR = VAR TRT VAR*TRT /HTYPE=3 DDFM = SATTERTHWAITE OUTP=SUGAR2;
RANDOM REP;
LSMEANS TRT VAR VAR*TRT  / PDIFF ADJUST = TUKEY;
ODS OUTPUT DIFFS=PPP;
ODS OUTPUT LSMEANS=MMM;
ODS LISTING EXCLUDE DIFFS;
ODS LISTING EXCLUDE LSMEANS;
RUN;
%INCLUDE 'C:\PDMIX800.SAS';
%PDMIX800 (PPP, MMM, ALPHA=0.05, SORT=YES);
RUN;
QUIT;
PROC MIXED data=SUGAR method=type3;
CLASSES REP VAR TRT;
MODEL SW = VAR TRT VAR*TRT /HTYPE=3 DDFM = SATTERTHWAITE OUTP=SUGAR2;
RANDOM REP;
LSMEANS TRT VAR VAR*TRT  / PDIFF ADJUST = TUKEY;
ODS OUTPUT DIFFS=PPP;
ODS OUTPUT LSMEANS=MMM;
ODS LISTING EXCLUDE DIFFS;
ODS LISTING EXCLUDE LSMEANS;
RUN;
%INCLUDE 'C:\PDMIX800.SAS';
%PDMIX800 (PPP, MMM, ALPHA=0.05, SORT=YES);
RUN;
QUIT;
PROC MIXED data=SUGAR method=type3;
CLASSES REP VAR TRT;
MODEL FIB1 = VAR TRT VAR*TRT /HTYPE=3 DDFM = SATTERTHWAITE OUTP=SUGAR2;
RANDOM REP;
LSMEANS TRT VAR VAR*TRT  / PDIFF ADJUST = TUKEY;
ODS OUTPUT DIFFS=PPP;
ODS OUTPUT LSMEANS=MMM;
ODS LISTING EXCLUDE DIFFS;
ODS LISTING EXCLUDE LSMEANS;
RUN;
%INCLUDE 'C:\PDMIX800.SAS';
%PDMIX800 (PPP, MMM, ALPHA=0.05, SORT=YES);
RUN;
QUIT;
PROC MIXED data=SUGAR method=type3;
CLASSES REP VAR TRT;
MODEL FIB2 = VAR TRT VAR*TRT /HTYPE=3 DDFM = SATTERTHWAITE OUTP=SUGAR2;
RANDOM REP;
LSMEANS TRT VAR VAR*TRT  / PDIFF ADJUST = TUKEY;
ODS OUTPUT DIFFS=PPP;
ODS OUTPUT LSMEANS=MMM;
ODS LISTING EXCLUDE DIFFS;
ODS LISTING EXCLUDE LSMEANS;
RUN;
```

```
%INCLUDE 'C:\PDMIX800.SAS';
%PDMIX800 (PPP, MMM, ALPHA=0.05, SORT=YES);
RUN;
QUIT;
PROC MIXED data=SUGAR method=type3;
CLASSES REP VAR TRT;
MODEL FIB3 = VAR TRT VAR*TRT /HTYPE=3 DDFM = SATTERTHWAITE OUTP=SUGAR2;
RANDOM REP;
LSMEANS TRT VAR VAR*TRT  / PDIFF ADJUST = TUKEY;
ODS OUTPUT DIFFS=PPP;
ODS OUTPUT LSMEANS=MMM;
ODS LISTING EXCLUDE DIFFS;
ODS LISTING EXCLUDE LSMEANS;
RUN;
%INCLUDE 'C:\PDMIX800.SAS';
%PDMIX800 (PPP, MMM, ALPHA=0.05, SORT=YES);
RUN;
QUIT;
PROC MIXED data=SUGAR method=type3;
CLASSES REP VAR TRT;
MODEL FIB = VAR TRT VAR*TRT /HTYPE=3 DDFM = SATTERTHWAITE OUTP=SUGAR2;
RANDOM REP;
LSMEANS TRT VAR VAR*TRT  / PDIFF ADJUST = TUKEY;
ODS OUTPUT DIFFS=PPP;
ODS OUTPUT LSMEANS=MMM;
ODS LISTING EXCLUDE DIFFS;
ODS LISTING EXCLUDE LSMEANS;
RUN;
%INCLUDE 'C:\PDMIX800.SAS';
%PDMIX800 (PPP, MMM, ALPHA=0.05, SORT=YES);
RUN;
QUIT;
PROC MIXED data=SUGAR method=type3;
CLASSES REP VAR TRT;
MODEL TRS1 = VAR TRT VAR*TRT /HTYPE=3 DDFM = SATTERTHWAITE OUTP=SUGAR2;
RANDOM REP;
LSMEANS TRT VAR VAR*TRT  / PDIFF ADJUST = TUKEY;
ODS OUTPUT DIFFS=PPP;
ODS OUTPUT LSMEANS=MMM;
ODS LISTING EXCLUDE DIFFS;
ODS LISTING EXCLUDE LSMEANS;
RUN;
%INCLUDE 'C:\PDMIX800.SAS';
%PDMIX800 (PPP, MMM, ALPHA=0.05, SORT=YES);
RUN;
QUIT;
PROC MIXED data=SUGAR method=type3;
CLASSES REP VAR TRT;
MODEL TRS2 = VAR TRT VAR*TRT /HTYPE=3 DDFM = SATTERTHWAITE OUTP=SUGAR2;
RANDOM REP;
LSMEANS TRT VAR VAR*TRT  / PDIFF ADJUST = TUKEY;
ODS OUTPUT DIFFS=PPP;
ODS OUTPUT LSMEANS=MMM;
ODS LISTING EXCLUDE DIFFS;
ODS LISTING EXCLUDE LSMEANS;
RUN;
%INCLUDE 'C:\PDMIX800.SAS';
%PDMIX800 (PPP, MMM, ALPHA=0.05, SORT=YES);
```

```
RUN;
QUIT;
PROC MIXED data=SUGAR method=type3;
CLASSES REP VAR TRT;
MODEL TRS3 = VAR TRT VAR*TRT /HTYPE=3 DDFM = SATTERTHWAITE OUTP=SUGAR2;
RANDOM REP;
LSMEANS TRT VAR VAR*TRT  / PDIFF ADJUST = TUKEY;
ODS OUTPUT DIFFS=PPP;
ODS OUTPUT LSMEANS=MMM;
ODS LISTING EXCLUDE DIFFS;
ODS LISTING EXCLUDE LSMEANS;
RUN;
%INCLUDE 'C:\PDMIX800.SAS';
%PDMIX800 (PPP, MMM, ALPHA=0.05, SORT=YES);
RUN;
QUIT;
PROC MIXED data=SUGAR method=type3;
CLASSES REP VAR TRT;
MODEL TRS = VAR TRT VAR*TRT /HTYPE=3 DDFM = SATTERTHWAITE OUTP=SUGAR2;
RANDOM REP;
LSMEANS TRT VAR VAR*TRT  / PDIFF ADJUST = TUKEY;
ODS OUTPUT DIFFS=PPP;
ODS OUTPUT LSMEANS=MMM;
ODS LISTING EXCLUDE DIFFS;
ODS LISTING EXCLUDE LSMEANS;
RUN;
%INCLUDE 'C:\PDMIX800.SAS';
%PDMIX800 (PPP, MMM, ALPHA=0.05, SORT=YES);
RUN;
QUIT;
PROC MIXED data=SUGAR method=type3;
CLASSES REP VAR TRT;
MODEL TONS = VAR TRT VAR*TRT /HTYPE=3 DDFM = SATTERTHWAITE OUTP=SUGAR2;
RANDOM REP;
LSMEANS TRT VAR VAR*TRT  / PDIFF ADJUST = TUKEY;
ODS OUTPUT DIFFS=PPP;
ODS OUTPUT LSMEANS=MMM;
ODS LISTING EXCLUDE DIFFS;
ODS LISTING EXCLUDE LSMEANS;
RUN;
%INCLUDE 'C:\PDMIX800.SAS';
%PDMIX800 (PPP, MMM, ALPHA=0.05, SORT=YES);
RUN;
QUIT;
PROC MIXED data=SUGAR method=type3;
CLASSES REP VAR TRT;
MODEL LBS = VAR TRT VAR*TRT /HTYPE=3 DDFM = SATTERTHWAITE OUTP=SUGAR2;
RANDOM REP;
LSMEANS TRT VAR VAR*TRT  / PDIFF ADJUST = TUKEY;
ODS OUTPUT DIFFS=PPP;
ODS OUTPUT LSMEANS=MMM;
ODS LISTING EXCLUDE DIFFS;
ODS LISTING EXCLUDE LSMEANS;
RUN;
%INCLUDE 'C:\PDMIX800.SAS';
%PDMIX800 (PPP, MMM, ALPHA=0.05, SORT=YES);
RUN;
QUIT;
```

APPENDIX H: PDMIX800 SAS MACRO FOR PROC MIXED

```
**** PDMIX800, for SAS Version 8 ******;
**** Modified 03-26-2002, error in by processing;
**** Modified 10-18-2001, printing changed again, turned off log notes;
**** Modified 6-8-2001, bug in slice and printing modified;
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*************************************************************
ORIGINAL REFERENCE:
Saxton, A.M.  1998.  A macro for converting mean separation output to letter
groupings in Proc Mixed.  In Proc. 23rd SAS Users Group Intl., SAS Institute,
Cary, NC, pp1243-1246.

PURPOSE:
This macro takes two data sets from Proc MIXED (Version 8), created by the
 DIFFS option on the LSMEANS statement. If an ADJUST= option is used,
the pdiffs from this are used, not the unadjusted defaults.
The pdiffs are converted to groups, labeled by numbers, and this
is merged onto the lsmeans data set.
The numbers are converted to letters, and for cases where more than
26 letters are needed, sections of letters are coded.  For example,
3 means might have the letters A, (2)A, and (3)A.  These 3 means
are all different, because although all have the letter A, each A
belongs to a different section, identified by (#).
CAUTIONS!!!!!!!
 Depends on computer using ASCII characters, with 32=blank and capital
 letters following this.
 Requires temporary SAS datasets MSGRPZZ, LSDVALZZ, PDTEMPZZ, PDTEMPZZZ, PDTEMPMZZ,
   so any existing SAS dataset with these names will be destroyed.
 There may be an IML limit of 90 total characters in the group
  letter labels, but space for 200 are hardcoded.
 Since SAS/IML is used, this must be installed on the computer, along
  with BASE and STAT.

Parameters.
```

```
 -First required parameter must name a dataset created by
  ODS OUTPUT DIFFS in proc mixed;
 -Second required parameter must name a dataset created by
  ODS OUTPUT LSMEANS in proc mixed;
 -Optional parameters, given in any order, case insensitive.
   SORT=YES  - printing of means is in order of least square mean
               value.  Any value other than YES leaves means in
               the proc mixed sort order.
   ALPHA=.05 - critical probability value for deciding if means
               differ or not.  The default is .05, and values must
               be between 0 and 1.
   WORKSIZE=1 - number of Kb of memory for IML to use.  This should
                only be needed in very extreme circumstances as IML
                dynamically increases memory as needed.
   TEST0=YES  -  this requests that 3 variables (df, t, p) not be
                included in the printing.  Any value other than NO
                prints all variables produced by the lsmeans.
   MIXFMT=NO -  this removes the formatting assigned by proc mixed,
                which helps compress the page width of the output.
                This also will result in the means and std. errors
              being rounded, which usually is desirable.  Any value
                besides NO retains the proc mixed formatting.
   NUMLET=200 - This specifies maximum number of letters that will
                be permitted.  Many means may possibly require many
                letters, but memory requirements get excessive.  The
                default of 200 should fail only in unusual cases. If
                failure occurs (error message in log), rerun with this
                option set higher.
    SLICE=variables  Effects containing all the slice variables will
                be subdivided, and mean separation reporting done within
                slice levels.  Note that all comparisons are made, just
                reporting of comparisons across slice levels is suppressed.
                This is useful to reduce the complexity of letter groupings.

Example of use.
  Assume the file pdmix800.sas, containing the macro code,
  is on the a: drive.  Then the code below will run MIXED, and run
  pdmix800 on the lsmeans.  MIXED is told not to print the means and
  pdiffs, using the ODS exclude statement, as
  pdmix800 does the printing in the more desirable format.
  Also shown are two optional parameters.
proc mixed;
 class block a b;
 model y = a b a*b;
 random block;
 lsmeans a b a*b/pdiff;
 ods output diffs=ppp lsmeans=mmm;
 ods listing exclude diffs lsmeans;
run;
%include 'a:pdmix800.sas';
%pdmix800(ppp,mmm,alpha=.01,sort=yes);
*****************************************************************/
%macro pdmix800(pname,lname,sort=NO,alpha=.05,worksize=1,test0=NO,
                mixfmt=YES,numlet=200,slice=);    %let printdebug=0;
*** check arguments;
%global bylistzz slicezz varlistzz;   **put out for possible use by backtrans;
%let slicezz=&slice;
```

```
%local dsid chk3 error1 error neweffectlength lastslicevar var adjust bylist;
  %let error=0;
  %if %length(&lname)=0 %then %let error=1;
  %if  %sysfunc(exist(&lname)) %then %do;
     %let dsid=%sysfunc(open(&lname,I));
    %let chk3=%sysfunc(varnum(&dsid,ESTIMATE));
    %if &chk3=0 %then %let error=2;
    %let chk3=%sysfunc(varnum(&dsid,EFFECT));
    %if &chk3=0 %then %let error=2;
    %let dsid=%sysfunc(close(&dsid));
  %end;
  %else %let error=1;

  %if &error>0 %then %do;
   %if &error=1 %then %put WARNING: Dataset &lname does not exist.;
   %if &error=2 %then %put WARNING: Dataset &lname was not made by proc mixed.;
  %end;
  %let error1=&error;

  %let error=0;
  %if %length(&pname)=0 %then %let error=1;
  %if %sysfunc(exist(&pname)) %then %do;
    %let dsid=%sysfunc(open(&pname,I));
    %let chk3=%sysfunc(varnum(&dsid,ESTIMATE));
    %if &chk3=0 %then %let error=3;
    %let chk3=%sysfunc(attrn(&dsid,nobs));
    %if &chk3=0 %then %let error=2;
    %let dsid=%sysfunc(close(&dsid));
  %end;
  %else %let error=1;
  %if &error>0 %then %do;
   %if &error=1 %then %put WARNING: Dataset &pname does not exist.;
   %if &error=2 %then %put WARNING: There are no observations in dataset &pname.;
   %if &error=3 %then %put WARNING: Dataset &pname was not made by proc mixed.;
  %end;
  %if (&error or &error1) %then %do;
   %put NOTE: PDMIX800 terminated due to errors in input values.;
   %goto skip;
  %end;
 %if &error %then %do;
   %put PDMIX800 terminated due to errors in input values.;
   %if &error=3 %then %put Alpha can only have values between 0 and 1.;
   %if &error=4 %then %put ADJUST=Dunnett output not supported.;
   %goto skip;
 %end;
** save setting of notes option;
%let notesval=notes;
options nonotes;
%put PDMIX800 03.26.2002 processing;
****need list of variable names, either sliced or not;
data _null_;
 *** First get unique list of all names used in BY statements;
 *** these come before the variable EFFECT, but include EFFECT in list;
 dsid=open("&lname",'i');
 length namlist $ 512;
 ii=1;
 value=varname(dsid,ii);
```

```
 do while (value ^= 'Effect') ;
   if ii=1 then namlist=value;
   else namlist=trim(namlist)||' '||value;
   ii=ii+1;
   value=varname(dsid,ii);
 end;
 call symput('bylistzz',compbl(namlist)); **list without effect;
 if namlist='' then namlist=value;
 else namlist=trim(namlist)||' '||value;
 namlist=trim(namlist);
 call symput('bylist',namlist);   **list with effect;
****************************************************;
*** Now get list of all class variables (always between effect and estimate);
 length list list1 list2 $ 3200;
 start=varnum(dsid,"EFFECT") +1;
 ii=1;jj=start;
 slicein=upcase("&slice");
 do while(ii);
  name=varname(dsid,jj);
  name1=upcase(name); **case sensitive names are returned by varname;
  type=vartype(dsid,jj);
  if name1 ^= 'ESTIMATE' then do;
    kk=indexw(slicein,name1);
    if kk=0 then do; list=compress(list||'='||name);
          if type='N' then
           list2= trim(list2)||' left('||trim(name)||left(")= '_' and") ;
          else list2= trim(list2)||' left('||trim(name)||left(")='' and") ;
    end;
    else do;
      if type='N' then
         list1= trim(list1)||' left('||trim(name)||left(")='_' or") ;
      else list1= trim(list1)||' left('||trim(name)||left(")='' or") ;
        end;
    jj=jj+1;
  end;
  else ii=0;
 end;
 list=substr(list,2);
 jj=length(list1); if jj>2 then list1=substr(list1,1,jj-2);
 list2=substr(list2,1,length(list2)-3);
 call symput('lastslicevar',scan("&slice",-1) );
 call symput('slice1',trim(list1));
 call symput('varlist1',trim(list2));
 list=translate(list,' ','=');
call symput ('varlistzz',trim(list));
run;
%if &printdebug=1 %then %do;
  %put bylist      &bylist;
  %put bylistzz    &bylistzz;
  %put varlistzz   &varlistzz;
  %put varlist1    &varlist1;
%end;
********** add variables to datasets ***************;
data pdtempzz; set &pname; by &bylist effect notsorted;
** if adjusted probs are not there, a LSD was used;
 if ADJP=. then do; ADJP=PROBT; ADJUSTMENT='LSD    '; end;
 length _mstech_ $ 30;
```

```
 if ADJUSTMENT ='' then _mstech_=compress('LSD(P<'||"&alpha"||')');
  else do;
    _mstech_=compress(ADJUSTMENT||'(P<'||"&alpha"||')' );
   if substr(ADJUSTMENT,1,7)='Dunnett' then call symput('error','4');
  end;
 *** numerical value check only possible in data step;
 if &alpha < 0.0 or &alpha > 1.0 then call symput('error','3');
 *** initalize slice indicator;
  sliceindzz=1;
  retain bygroup 0;
  if first.effect then bygroup=bygroup+1;
run;
%if %length(&slice) ne 0 %then %do;
********************************************************************;
********************************************************************;
*** sort, edit, relabel diff and mean data for the slice option ***;
*** this works by redefining effects that are being sliced ***;
*** Example:  In a 2*2 factorial, slicing the A*B interaction by A
***  means only 2 comparisons are needed of the 4*3/2=6 possible.
***  These are A1B1-A1B2  and  A2B1-A2B2;
*** sort and relabel lsmeans;
%if %length(&varlistzz)=0 %then %put ERROR: No variables left after slicing.;
%else %do;
data pdtempmzz; set &lname; by &bylist effect notsorted;
  retain bygroup 0;
  if first.effect then bygroup+1;
  sliceindzz=1;
run;
proc sort data=pdtempmzz; by bygroup &slice;
data pdtempmzz ;   set pdtempmzz; by bygroup &slice;
  retain slicecntzz  dothiseffectzz ;
 if first.bygroup then do;
  dothiseffectzz=0;
  slicecntzz=0;
  *****test if effect should be sliced;
  sliceynzz=1;
  if not(&slice1) then do; **no slice vars missing;
       if not(&varlist1)  then dothiseffectzz=1;
  end;
 end;
 if first.&lastslicevar then  slicecntzz+1;
 if dothiseffectzz=1 then sliceindzz=slicecntzz;
 drop sliceynzz slicecntzz;
run;
*** now fix up diffs dataset;
data pdtempzzz; set pdtempmzz; by bygroup  &slice notsorted;
***copy slice definitions only ***;
 if first.&lastslicevar;
run;
proc sort data=pdtempzz ; by bygroup &slice;
data pdtempzz; merge pdtempzz (in=have)
             pdtempzzz(keep= &slice dothiseffectzz bygroup sliceindzz);
   by bygroup &slice;
   if have;
***compared factor levels must match on all slice variables;
  discardzz=0;
  if dothiseffectzz then do;
```

```
   %let ii=1;
   %let var=%scan(&slice,1);
   %do %while(%length(&var) ne 0);
       %let var2=_&var;
       %if %length(&var2)>32 %then %let var2=%substr(&var2,1,32);
       if &var ne &var2 then discardzz=1;
     %let ii=%eval (&ii+1);
     %let var=%scan(&slice,&ii);
   %end;
   if discardzz then delete;
  end;
 drop discardzz dothiseffectzz bygroup sliceindzz;
run;
data pdtempmzz; set pdtempmzz;
 drop  dothiseffectzz bygroup sliceindzz;
run;
%end;
%end;
%else %do;
  **must be created if no slicing;
  data pdtempmzz; set &lname; run;
%end;
**************************************************************;
*** ready to process for differences within each effect ***;
proc iml worksize=&worksize; reset nolog fw=7;  printdebug=0;
 alpha=&alpha;
 use pdtempmzz;  **for reading later;
 **** create mean separation output dataset with length 200;
 temp=j(1,&numlet,'0'); msgroup=rowcatc(temp);
 ADJUSTMENT='                              ';
 create msgrpzz var{msgroup bygroup lsmrank ADJUSTMENT};
 **** create indexes of effect and by group locations;
 test='a'; ii=1;
 *** the diffs dataset from mixed has all the BY and CLASS
 ***  variable names ordered before the variable ESTIMATE.
 *** Names beginning with underscore are duplicates.
 *** Get all these variable names and read in levels;
 use pdtempzz;
 varlist= "&bylistzz &slice &varlistzz";
 value='a'; ii=1;
 do while (value ^= '') ;
  value=scan(varlist,ii);
  if value ^= '' then do;
    *** the BY variables are not guaranteed to be character,
    *** so convert them if necessary;
     read all var value into hold;
     if type(hold)='N' then level=level||char(hold);
     else level=level||hold;
     free hold;
  end;
  ii=ii+1;
 end;
if printdebug=1 then print  varlist level;
 if ncol(level)=0 then do;
   file log;
   put "NOTE: No variables found for use in &pname.";
   dataerr=1;
```

```
 end;
 else dataerr=0;
 if dataerr ^= 1 then do;
   call change(level,'','-');
   level=rowcatc(level);
   idx=1;
   dim=nrow(level);
if printdebug=1 then print dim level;
 ***search down for number of comparisons in each section;
 ***read number of rows involving first mean to get number of means,
   then calculate number of comparisons;
  byby=0;
  do jj=1 to dim;
    first=level[jj,1];
    byby=byby+1;
    **go to end of comparisons with mean 1;
    kk=jj; flag=1;
    do while(flag=1);
      kk=kk+1;
      if(kk > dim) then flag=0;
      else if (level[kk,1] ^= first) then flag=0;
    end;
    num=kk-jj+1;
    idx=idx || idx[1,byby] + num;
    jj=jj-1+num*(num-1)/2;  ** skip to next section;
   end;
  free level;
 end;
if printdebug=1 then print idx byby;
 ** BIG BB loop through rows of prob data
 ** subsetting out block dealing with each effect;
 pptr=1;  **points to where probs start for current means;
 do bygroup = 1 to byby;

  dim= idx[1,bygroup+1]-idx[1,bygroup];
  nn= dim*(dim-1)/2;

  **********************************************************;
  **for sorting letters need descending order, and antiranks;
  setin pdtempmzz;
  range=idx[1,bygroup] : idx[1,bygroup+1]-1 ;
  read point range var {ESTIMATE} into lsmcur;

  **stupid rank function fails on missing values;
  **so must temporarily make them non missing;
  test=lsmcur[><,]-1.e-30;
  locmiss=loc(lsmcur=.); kk=ncol(locmiss);
  if kk>0 then lsmcur[locmiss,]=test;
  lsmrnk=dim+1-rank(lsmcur);
  if kk>0 then lsmcur[locmiss,]=.;
  lsmarnk=lsmrnk;
  lsmarnk[lsmrnk,]=(1:(dim))`;
if printdebug=1 then print pptr nn;
**********************************************************;
**** get prob file data for these means.
  _adjp_ contains the probs, no matter what adjust method;
  setin pdtempzz;
```

```
  range=pptr:pptr+nn-1;
  read point pptr var {_mstech_} into ADJUSTMENT;
  read point range var {ADJP} into data;
  pptr=pptr+nn;
if printdebug=1 then print data;
  *** put p values into matrix;
  p = j(dim,dim,0);
  kk=1; do ii=1 to dim-1; do jj=ii+1 to dim;
    if data[kk,1]=. then  p[jj,ii]=1;
    else  p[jj,ii] = data[kk,1];
    p[ii,jj]=p[jj,ii];  **fill in upper triangle for next sort;
    kk=kk+1;
 end;end;
  *** sort matrix by lsm value, so high mean gets first letter;
  temp=p;
  p[,lsmrnk]=temp;
  temp[lsmrnk,]=p;
  p=temp; free temp;
  if nn>&numlet then maxlet=&numlet; **memory use limit;
  else maxlet=nn+1;
  group = j(dim, maxlet, 0);
  members=j(dim,1,0);
if printdebug=1 then print p dim data;
  gcode=1; ngroup=1;
  do ii=1 to dim;
     kk=0;
     flag=0;
     do jj=ii+1 to dim;  * go down row, find group members ;
        if p[jj,ii] > alpha then do;   * jj and ii are the same ;
           * check jj against members ;
           do mm=1 to kk ;
              ll=members[mm,1];
              if jj>ll then test1=p[jj,ll];
              else    test1=p[ll,jj];
              if test1<0 then test1=-test1;
              if(test1 < alpha) then goto jmp0; * need new group ;
           end;
           jmp0:
           if mm=kk+1 then do;
              do mm=ii+1 to dim;
                 if mm=jj then mm=mm+1; *skip jj (on diagonal);
                 if mm>dim then go to jmp2;
                 if jj>mm then test1=p[jj,mm];
                 else    test1=p[mm,jj];
                 if test1 > alpha && -p[mm,ii] > alpha then do;
                 * previous grouped mean mm may belong in this group ;
                 * so check if already in and current members;
                 * dont conflict ;
                    do ll=1 to kk;
                       nn=members[ll,1];
                       if nn=mm then goto jmp1;
                       if nn<mm then test1=p[mm,nn];
                       else      test1=p[nn,mm];
                       if(test1<0.0) then test1=-test1;
                       if(test1<alpha) then goto jmp1;
                    end;
                    jmp1: if(ll=kk+1)then do;
```

```
                    group[mm,ngroup]=gcode;
                    kk=kk+1; members[ll,1]=mm;
                 end;
              end;
           end;
    jmp2:  p[jj,ii]=-p[jj,ii];  * set so not put in next group ;
           do mm=1 to kk;
              ll=members[mm,1];
              * set so not used again ;
              if ll<jj then do;
                if p[jj,ll]>0 then  p[jj,ll]=-p[jj,ll]; end;
              else do;
              if p[ll,jj]>0 then p[ll,jj]=-p[ll,jj]; end;
           end;
           group[jj,ngroup]=gcode;
           kk=kk+1;  members[kk,1]=jj;
        end;
        else flag=1;
     end;
  end;
  if(kk=0) then do;  * no members ;
     do jj=1 to ngroup until (group[ii,jj] ^= 0) ; end;
     * not in a group yet, so set flag ;
     if(jj=ngroup+1) then   kk=kk+1;
  end;
  if(kk^=0) then do;   * need to set current mean ;
     group[ii,ngroup]=gcode;
     ngroup=ngroup+1; gcode=gcode+1;
     if ngroup > &numlet then do;
       ** number of letters needed exceeded maximum;
       jj=dim; ii=dim; **stop loops this way to avoid warnings;
       bygroup=byby; dataerr=1;
       call symput('error','1');
     end;
  end;
  if(flag^=0) then ii=ii-1; * need another group for this mean;
end;
if dataerr=0 then do; **skip below if error;
ngroup=ngroup-1;
group=group[,1:ngroup];
***** this section just takes the groups identified by numbers
      above and converts numbers to letters.  This depends on
      the ASCII character definitions, eg. 64 value below is what
      gets capital letters;
   *** write out letters;
   kk=nrow(group);
   do ii=1 to kk;
     gc='';nsect=1;
     do jj=1 to ngroup;
       mm=group[ii,jj];
       if mm > 0 then do; ** blanks are 0, do not do them;
         sect=floor((mm-1)/26);  *** 26 letters in alphabet;
         offset=mm-sect*26;
         sect=sect+1;
         if sect > nsect then do;
            nsect=sect;
            gc=gc||"("||char(sect)||")";
```

```
          end;
          gc=gc||byte(64+offset);
        end;
      end;
      lsmrank=lsmarnk[ii,1];
      msgroup=rowcatc(gc);
      ** save letters, by group and sort info;
      append var {msgroup bygroup lsmrank ADJUSTMENT};
    end;
  end; **dataerr;
end;  ** for the big bb loop over effect sections;
quit;
%if &error=1 %then %do;
  %put ERROR: PDMIX800 terminated due to exceeding NUMLET limit.;
  %goto skip;
%end;
**** put group letters back in original lsm order;
**** they were sorted so largest mean gets letter A;
proc sort data=msgrpzz; by bygroup lsmrank;
**** if means data set has single means (eg 0 df)
     then sort these to the bottom so they do not
     merge with the msgrp output;
data pdtempmzz; set pdtempmzz; by EFFECT notsorted;
 if first.EFFECT and last.EFFECT then
  df0=1;
 else df0=0;
run;
proc sort; by df0;
**** merge letters with means and print ****;
data msgrpzz; merge pdtempmzz msgrpzz;
drop lsmrank df0;
 label msgroup='Letter Group';
 if ESTIMATE=. then do;
   **do not print for missing means;
   msgroup='';
 end;
 %if %upcase(&mixfmt)=NO %then %do; format _all_; %end;

run;
data pdtempmzz; set pdtempmzz; drop df0; run;
******************************************************************;
**** before printing, add the lsdvalues;

proc means noprint data=pdtempzz; by &bylist &slice notsorted;
 id df adjustment;
 var STDERR ;
 output out=lsdvalzz n=numcomp mean=meanse max=maxse min=minse;
run;
data lsdvalzz; set lsdvalzz;
 if upcase(substr(adjustment,1,3))='LSD' then critt=tinv( (1-&alpha/2),DF);
 if upcase(substr(adjustment,1,3))='BON' then critt=tinv( 1-&alpha/(2*numcomp), DF);
 if upcase(adjustment)='SIDAK' then do;
       prob=exp( log(1-&alpha/2) /numcomp );
       critt=tinv( prob  , DF);
 end;
 if upcase(adjustment)='SCHEFFE' then do;
      numdf=-1+(sqrt(1+8*numcomp)+1)/2;
```

```
       critt=sqrt(numdf*finv(1-&alpha,numdf,DF));
 end;
 if upcase(substr(adjustment,1,5))='TUKEY' then do;
       numdf=(sqrt(1+8*numcomp)+1)/2;  ** number of treatments;
       critt=probmc('RANGE', . , 1-&alpha,DF,numdf);
put critt;
       critt=critt/sqrt(2);  **adjust for tukey needing sd of mean, not diff;
 end;
 AvgSigDiff=meanse*critt;
 MaxSigDiff=maxse*critt;
 MinSigDiff=minse*critt;
 keep &bylist &slice avgsigdiff maxsigdiff minsigdiff;
 format minsigdiff maxsigdiff avgsigdiff best7. ;
 put adjustment ' values for ' &bylist &slice ' are ' avgsigdiff ' (avg) ' minsigdiff ' (min) '
maxsigdiff  ' (max).' ;
run;
proc sort; by &bylist &slice;
proc sort data=msgrpzz; by &bylist  &slice;
proc sort; by ADJUSTMENT bygroup EFFECT;
******** print mean separation ************;
%if %upcase(&sort)=YES %then %do;
 proc sort data=msgrpzz; by ADJUSTMENT bygroup EFFECT descending ESTIMATE;
%end;
 %if %upcase(&test0)=NO  %then %do;
  data msgrpzz; set msgrpzz;
     drop tvalue probt df;
  run;
%end;
proc print data=msgrpzz label ;
 by  effect adjustment bygroup notsorted;
 label bygroup='  Set'
       adjustment='  Method';
run;
*** restore notes option;
options &notesval;
%skip:
%mend;
```

VITA

Frederick "Fred" Reuben Posey was born on April 6, 1976, and raised on a farm in the hills of Sicily Island, Louisiana. He graduated from Sicily Island High School in May 1994 and Northeast Louisiana University in December 1997 with a Bachelor of Science degree. His major was agricultural-business and he earned minors in agronomy, ag-economics, and agriculture.

Fred worked exclusively on the family farm from about the age of five until late fall of 1989 when an unfortunate farm accident happened to his father, which ended expansion of the family farm. He continued with responsibilities on the farm, and began working summers as a row crop field scout for Agricultural Management Services, Inc. (AMS) in 1990 - 1996. In 1996, he was certified by the Louisiana Department of Agricultural and Forestry as a licensed crop consultant. He worked closely with Roger Carter (crop consultant and president of AMS) in the summers of 1996 and 1997 as a crop consultant gaining experiences and developing a deep love and understanding of all aspects of production agricultural.

He was married to Rebecca "Becky" Claudia Harvey of St. Francisville, Louisiana, on March 22, 1997 in St. Francisville, Louisiana. They lived in Wisner, Louisiana, until 1998 when they moved to St. Francisville where they currently live today. They have one daughter, Claudia Catherine, born April 6, 1999.

After graduation from college in 1997, and being faced with the agricultural economic situation of North Louisiana, he began working in February of 1998 as a research associate at the LSU AgCenter in the Department of Agricultural-Economics managing farm production budgets for row crops in North Louisiana and sugarcane in South Louisiana. In the early summer of 1999, he switched to a 80% Entomology Department Research Associate and Graduate Student position for Dr. T. E. Reagan in the sugarcane program, which includes biological control enhancement, pesticide application technology, variety resistance development, and implementing a narrow range/minimum risk environmentally positive IPM system. He also had a 20% entomology responsibility with the Sugar Research Station at St. Gabriel, Louisiana (Dr. Kenneth Gravois, Head). At St. Gabriel, he had been charged with making evaluations and recommendations for treatment and management of insect problems for the various project leaders who conduct sugarcane research at the station. In accordance with guidelines of Dr. T. E. Reagan's program, he also conducted variety assessment against the sugarcane borer for cultivars at early stages of the variety development program. In April of 2003, he returned to his first love, crop consulting, after assuming a full-time position with Calvin Viator, Ph.D., and Associates, as a crop consultant in South Louisiana working mainly with sugarcane, soybeans, and wheat.